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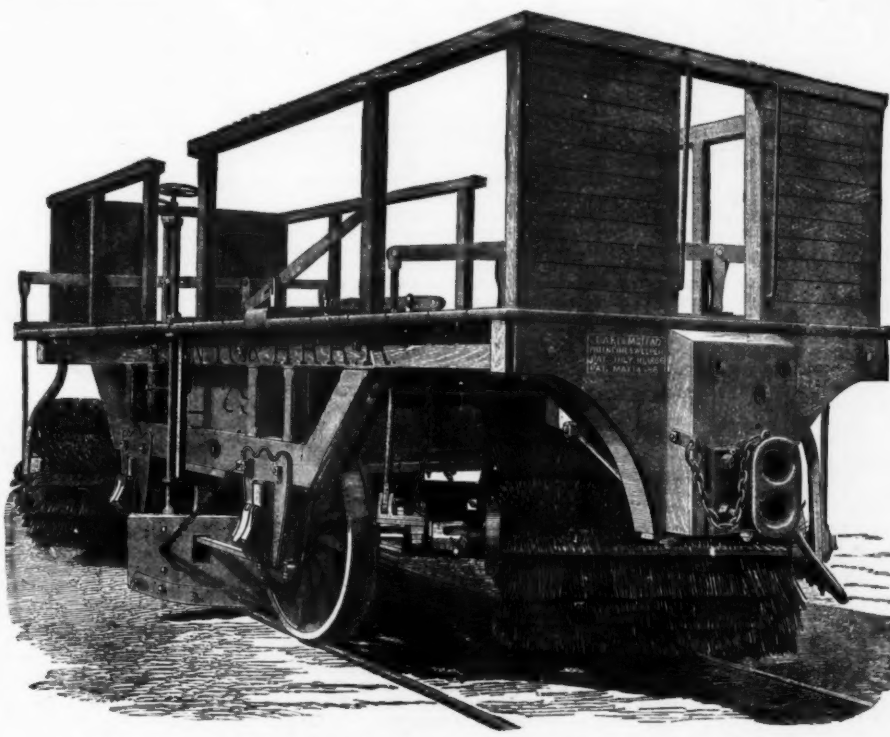
OLMSTEAD'S RAILROAD TRACK SWEEPER.

The same principle that leads nations to prepare for war in times of peace should induce railroad companies to prepare in summer for snow storms in winter. We give from the *Railroad Gazette* an engraving of a sweeping machine for sweeping snow from railroad tracks, designed and constructed by Mr. E. A. F. Olmstead, who has charge of the car shops of the Hudson River Railroad at Thirtieth street in New York. This machine is adapted for sweeping snow from the tracks of steam or horse railroads. One of these was built for the New York Central and Hudson River Railroad, and has been used for eight years for sweeping the tracks of that company in the streets and yards in New York city, and worked so well that machines were built for cleaning the snow from the main line.

The sweeping mechanism consists of two cylindrical brooms 44 in. in diameter, arranged diagonally under the body of the sweeper. These brooms are made of rattan, and they are geared from bevel wheels with 25 teeth on the axles to other similar wheels with 13 teeth on the broom shaft, so that the brooms make very nearly two revolutions to one of the axle. They will sweep seven feet wide and remove snow 15 in. deep when running at a speed of 20 miles per hour.

The whole machine is 21 ft. long and 6 ft. 4 in. wide. The wheels which carry it are 42 in. in diameter. The brooms can be raised and lowered, and thus adjusted to the track, by means of rods, one of which is attached at each end of the broom shaft and is operated with a screw and can be raised and lowered in a moment.

These sweepers can be run in front or behind an engine, and it is said that they will sweep equally well running either way, and will leave the track for all practical purposes perfectly clean.



OLMSTEAD'S IMPROVED RAILROAD TRACK SWEEPER.

NEW NARROW GAUGE LOCOMOTIVE.

We illustrate a single Fairlie engine, designed by Mr. G. P. Spooner for the well known Festiniog Railway, on which line it is now running. The gauge of the line, it will be remembered, is rather less than 2 ft. The engine is carried on two bogies, but only the first one is provided with cylinders.—*The Engineer.*

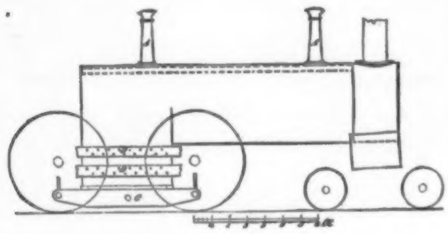
THE EDDY LOCOMOTIVE.

In a recent number of the *Railroad Gazette*, Mr. F. G. Woodward gives an outline illustration of some of the distinctive features of an engine which has been the outgrowth of many years of hard experience in working the heavy grades of the Boston and Albany Railroad.

Most of the engines of this company are now of this type, and they have proved eminently efficient and satisfactory. It will be seen by the outline that Mr. Eddy has wisely ad-

SINGLE BOILER FAIRLIE ENGINE FOR THE FESTINIOG NARROW-GAUGE RAILWAY.
MR. SPOONER, C.E., PORTMADOC, ENGINEER.

hered to the no dome, flush top style of boiler; dry steam being supplied to the cylinders by means of a perforated pipe lying close up to the crown sheet of the boiler (see dotted lines), the perforations being made only in the upper side of the pipe; the perforated area decreasing in width from the center toward each end of the pipe so that the tipping of the engine on the grades shall not throw water into the pipe. The aggregate area of the perforations exceed by several fold the area of the cross section of the pipe, hence there can be no danger of water entering the pipe by suction. The throttle valve is placed in the smoke arch close to the cylinders. This is another commendable feature of the engine, as it permits but little waste of steam and time in starts and stops.



The springs and equalizing levers are arranged in a pair of stout plate iron girders (*C*) placed beneath the mud ring of the firebox, there being just room enough between them for the ash pan, their outer face being about flush with the face of the boiler. This arrangement allows of a much wider firebox than usual. The side bars (*I*), which carry the main boxes being only an inch or an inch and an eighth in thickness where they pass the firebox and but seven or eight inches wide, which gives them ample strength. The stand pipes (*A*) discharge the escaping steam from the safety valves above the outlook of the engineer.

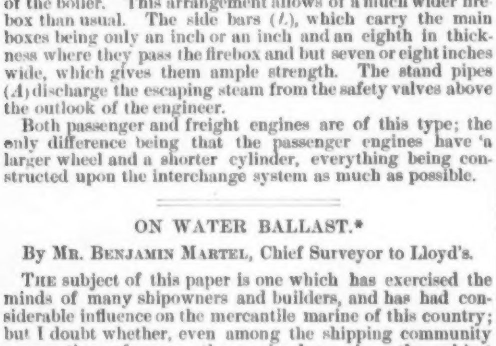
Both passenger and freight engines are of this type; the only difference being that the passenger engines have a larger wheel and a shorter cylinder, everything being constructed upon the interchange system as much as possible.

ON WATER BALLAST.*

By MR. BENJAMIN MARTEL, Chief Surveyor to Lloyd's.

THE subject of this paper is one which has exercised the minds of many shipowners and builders, and has had considerable influence on the mercantile marine of this country; but I doubt whether, even among the shipping community—excepting, of course, those who have given the subject special attention—its history and commercial importance are fully understood. If I am right in this view, my paper may not be uninteresting to this meeting. The question of double bottoms is so mixed up and associated in the mercantile marine with that of water ballast, that it has, I think, a somewhat different significance from the idea which prevails as to double bottoms in the Royal Navy. In the latter, as I take it, double bottoms are fitted, as it was in the Great Eastern, chiefly as a source of additional strength and security in the event of accident occurring to the outer bottom; whereas in the mercantile marine they are fitted as sources of commercial profit and convenience, although, of course, the question of safety is not entirely ignored. It is, however, from the commercial point of view that I wish principally to treat the subject, and I think I cannot do better, in the first place, than glance briefly at the early adoption of water ballast in mercantile ships. This occurred about twenty-five years ago in some of the steam colliers trading from the northeastern ports to London. In fact, the general adoption of water ballast in merchant steamers owes its existence entirely to our steam colliers. When the coal trade from the north to London was carried on by sailing colliers, the question of ballasting on every return voyage was not only one

FIG. 1.



which involved considerable extra cost to the consumers, but also occasioned a serious inconvenience, to which some of the north-eastern ports, even at the present day, by their unsightly mounds or ballast heaps bear witness. On the vessel entering the river, the ballast had to be disposed of; and this was done by discharging it on to the river side, thus rendering valuable land unsuitable for industrial purposes. The first attempts made to overcome these objections appear curious when viewed in the present day; but they answered a valuable purpose in preparing the way for more mature plans, and showing the practicability of making water ballast commercially successful. One of these was the adoption of strong canvas bags, which were filled with water for ballast, and on the termination of the voyage the water was discharged into the hold, and pumped out of the vessel. This plan, however, found but

FIG. 2.

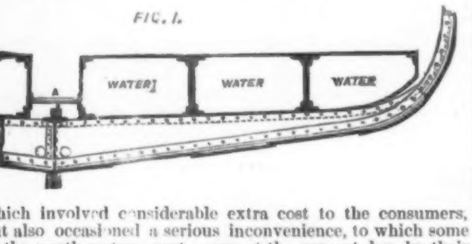
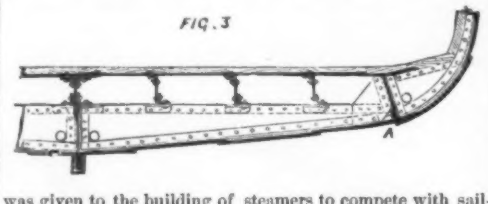


FIG. 15

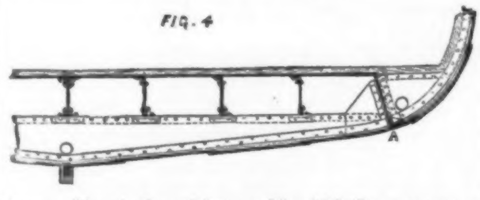
little favor, as the bags soon became chafed by the rolling of the vessel, and they sometimes tended to endanger her safety by bursting while she was performing her voyage. The John Bowes, built at Newcastle in 1852, was the first screw collier in which temporary appliances for carrying water ballast were adopted, and the comparative success of these means led to the building of a vessel with tanks fitted in the ship for containing the water ballast. This vessel was the steamship Samuel Laing, of 609 register tons, built in 1854, by Messrs. Palmer Brothers, at Jarrow, for Messrs. John Fenwick and Sons, of London. These tanks consisted of iron, made to the form, and fitted in the bottom of the vessel, as shown in Fig. 1. The Samuel Laing is still employed as a collier, and the tanks originally fitted remain serviceable in her at the present day. Immediately following this, the same builders built the steamship Rouen, and fitted an inner bottom, entering the structural arrangement of the vessel similar in principle to the double bottoms now fitted. The adaptation of water for ballasting steam colliers effected quick despatch, together with other attendant economy, and showed that steamers could successfully compete with the sailing colliers and railways. This naturally led to the employment of other similar vessels in this trade, and, with the increase of number, improvements were made in the construction of water ballast tanks, or double bottoms. Great economy having been effected in steam colliers by the introduction of water ballast, which could be quickly run into the vessel while she was discharging, or pumped out whilst proceeding with the loading, steps were taken to secure similar advantages in steam vessels employed in the Mediterranean, Baltic, and general home trades; and an impetus

FIG. 3



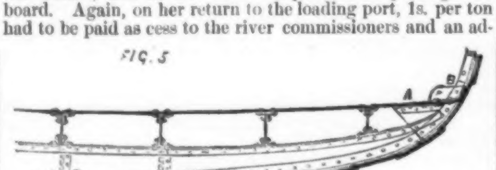
was given to the building of steamers to compete with sailing vessels in the European trade. At the present time provision is made for water ballast in most of the large steamers treading to the East, and all parts of the world. And the coal carrying trade on our coasts now principally done by steamers owes its present large dimensions to the introduction of water ballast, which has contributed in no small degree to enable steamers to compete successfully, and prevent this trade from becoming a monopoly by the railways, with its attendant evils to the coal consumers of the South. The reason for this is easily seen. As we have said, one of the greatest elements in the successful competition maintained by

FIG. 4



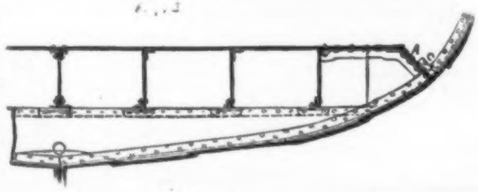
steam colliers is the quickness with which the passages are made, the saving of cost and time in ballasting, and the great facilities afforded at each end of the voyage for loading and discharging, as compared with sailing vessels. A sailing collier, carrying from 250 to 400 tons of coals, occupied, on an average, three weeks in making the voyage from the Tyne to the Thames, and when she arrived at the port of discharge the shipper or purchaser had, by an old trade custom of the port, the power of restricting the output to forty-nine tons per day. Thus, a vessel carrying 400 tons of coal might be detained nine or ten days in discharging. Then comes the comparatively costly process of ballasting. In the first place there was 1s. per ton to be paid to the Trinity lighters for the ballast, and an additional 6d. per ton for putting it on board. Again, on her return to the loading port, 1s. per ton had to be paid as cess to the river commissioners and an ad-

FIG. 5



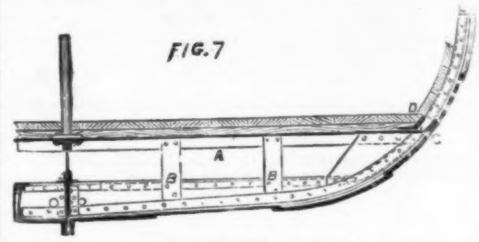
ditional 10d. per ton for depositing it on the river side. The steamers, on the other hand, with the means of carrying water ballast, were much more favorably situated. The voyages of these vessels from the Tyne to London occupy about thirty-six hours; and in the place of being restricted to the old rate of discharge of forty-nine tons per day, facilities are provided—the steam collier companies having become strong enough to break through the old custom limiting the output, and it is no uncommon thing to discharge 150 tons per hour. As the discharging proceeds, water

FIG. 6



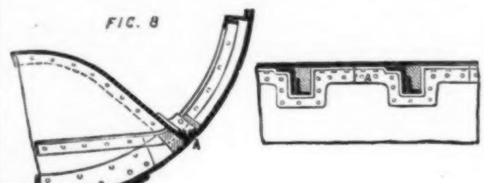
ballast is run into the double bottom, and it costs nothing for taking in, and but little for discharging, and the facilities thus afforded enable these vessels to make as many as sixty voyages from Newcastle to the Thames during the year. The number of voyages has risen, I believe, in the case of one vessel, to seventy-two per annum. The result of this is, that whereas nearly the whole of this trade would, in all probability, have been lost to shipowners, had water ballast steamers not been introduced and developed, we find that, during the year 1876, 3,273,442 tons of coals brought into London were sea-borne; and this cannot fail to produce a beneficial effect on the market. Whilst, however, the great advantages arising from the introduction of water ballast may thus be clearly seen in vessels engaged in the coasting coal trade, its economical use and advantages are not so readily admitted by some for vessels engaged in foreign trades. It is doubtless found unnecessary to carry water ballast in certain specific trades; but when we consider the great facilities afforded by it for trimming steamers in all situations, whilst avoiding heavy ballast charges, with the consequent much heavier expenses attending detention, I think it can be pretty plainly shown that there are very few steam vessels indeed where some kind of arrangement for carrying water ballast would not be an advantage. In fact, for steam vessels engaged in general trades, and having often to seek cargoes at various ports, it has become a prime necessity, and may well be allowed to take its place by the side of compound engines, as an important economical intro-

FIG. 7



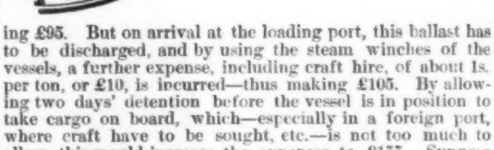
duction into this description of vessel. To convey an idea of the approximate yearly saving to a steamer engaged in a few general trades, I will give a few examples; but it must be understood that in doing so I am merely glancing at the subject, and that many circumstances might arise, well known to the owners of this class of vessels, by which the saving shown might be easily doubled. I will take first a steamer built for the Mediterranean trade, and costing about £20,000. Such a vessel will make, say, four voyages in the year. As a rule she would load to a Mediterranean port, thence go in ballast to her grain-loading port in the Black Sea. This vessel would require about 200 tons of ballast, and assuming a moderate charge for dry ballast of 2s. per ton, this would amount to £20; supposing 65 tons per day could be obtained, the detention caused in shipment, at the moderate calculation of £25 per day, would be an additional £75—thus mak-

FIG. 8



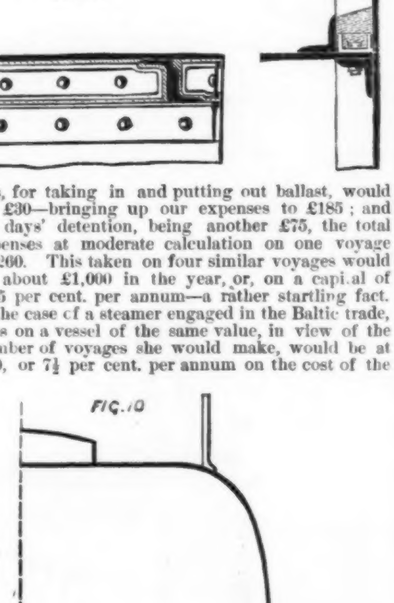
ing £95. But on arrival at the loading port, this ballast has to be discharged, and by using the steam winches of the vessels, a further expense, including craft hire, of about 1s. per ton, or £10, is incurred—thus making £105. By allowing two days' detention before the vessel is in position to take cargo on board, which—especially in a foreign port, where craft have to be sought, etc.—is not too much to allow, this would increase the expenses to £155. Suppose now the steamer to be ordered on arrival, off Falmouth, to some port to discharge cargo from which an outward freight could not be obtained; this same process of ballasting, with its attendant expenses and detention, must again occur—as such a vessel, not being a regular liner, would have to proceed in all probability to Wales or the north of England, or other coal port. This additional cost, allowing 3s. per ton

FIG. 9



on 200 tons, for taking in and putting out ballast, would amount to £30—bringing up our expenses to £185; and with three days' detention, being another £75, the total cost of expenses at moderate calculation on one voyage would be £260. This taken on four similar voyages would amount to about £1,000 in the year, or, on a capital of £20,000, to 5 per cent. per annum—a rather startling fact. If we take the case of a steamer engaged in the Baltic trade, the expenses on a vessel of the same value, in view of the greater number of voyages she would make, would be at least £1,500, or 7½ per cent. per annum on the cost of the

FIG. 10

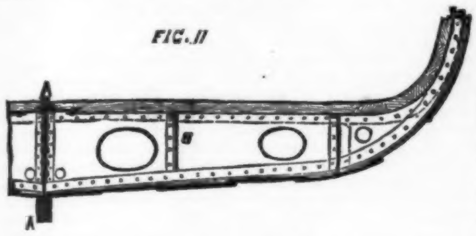


vessel. Nor are the advantages of water ballast confined to steamers in the European trade. If we consider the coasting trade of China—a most important trade, particularly between Saigon and Hong Kong—it is questionable whether steamers could have driven the sailing vessels from this trade but for the economical advantages of water ballast. Notwithstanding the high price of coal in those waters—viz., 40s. to 60s. per ton—the facilities afforded by water ballast

* Institution of Naval Architects.

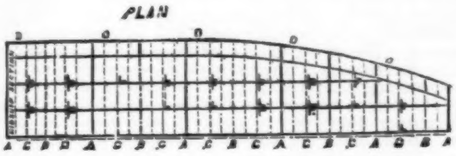
have enabled steamers so adapted to carry on the trade at freights at which it is found sailing vessels cannot exist. Some eminent builders, I know, have expressed doubts as to its desirability in steamers engaged in the China trade; but I know steamers engaged in bringing home tea and other valuable cargoes, which are provided with facilities for carrying nearly 300 tons of water ballast, in which it is carried with perfect safety, and found to be most convenient and economical. Recent circumstances have shown in a very striking manner the great benefits arising from large steamers, engaged in the India trade, being provided with facilities for the use of water ballast. During the recent

FIG. 11



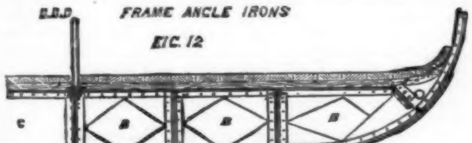
famine in India, the great demand for steam tonnage caused every available steamer there to be employed at exceptionally high freights—as much, in fact, as £3 15s. per ton was given for carrying rice to Madras, a run of four days only. The result of this great demand was to fill Madras Roads with a greater amount of tonnage than had ever anchored there before. This naturally led to exorbitant demands being made by the native boatmen, and it was with the utmost difficulty they could be induced to carry ballast to steamers which were not adapted for carrying water ballast at six rupees per ton—or about ten or twelve times the ordinary cost; and even at this exorbitant charge such steamers might have to wait two months for an amount of 200 tons Many of the large steamers, under these circumstances, which were not fitted for water ballast, had to keep part of their former cargo on board, and go down to Pondicherry, where dry ballast was obtained at a reasonable rate, and, after getting ballasted, had to return to Madras to discharge the remainder of the cargo, and then start to a loading port for rice. The great loss thus incurred at such a time, when employment was so profitable, can be easily understood. In many cases, I believe it amounted to at least

PLAN



A.A.A. CONTINUOUS DEEP FLOOR PLATES
B.B.B. BRACKET PLATES
C.C.C. VERTICAL ANGLE IRON STIFFENERS
D.D.D. FRAME ANGLE IRONS

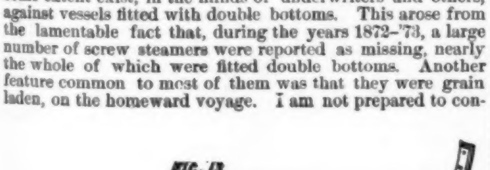
FIG. 12



£300 per voyage. This experience, I know, has induced the owners of some of these large steamers to have some kind of provision fitted to them for carrying water ballast, when so required. I need not dwell longer on this part of the subject, but I may perhaps add that I have a strong opinion that before long scarcely a steamer will be built without some kind of adaptation for carrying, in cases of emergency or occasional divergence of trade, sufficient water ballast to enable her to shift from port to port.

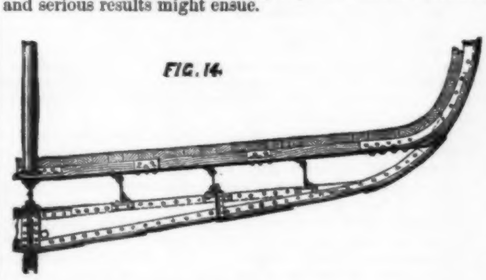
And here I think it may be useful to refer to the great prejudice which existed a short time ago, and does still to some extent exist, in the minds of underwriters and others, against vessels fitted with double bottoms. This arose from the lamentable fact that, during the years 1872–'73, a large number of screw steamers were reported as missing, nearly the whole of which were fitted double bottoms. Another feature common to most of them was that they were grain laden, on the homeward voyage. I am not prepared to con-

FIG. 13



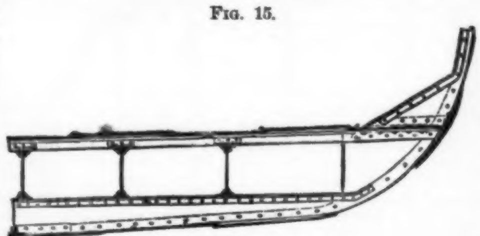
tend that the existence of double bottoms in some of these vessels did not contribute in some measure to the disasters; because some of them were inordinately high, and were fitted in vessels whose dimensions and forms would necessarily have rendered them tender ships. There can be little doubt that those disasters were brought about by a combination of most unfortunate circumstances. A tendency to carry double bottoms up to excessive heights had been developing itself, without any compensating increase of beam. And vessels of this type were put into the Atlantic trade to load grain in bulk at time when the necessity for extreme caution in securing such cargoes from shifting was not sufficiently well attended to. The sad experience then gained, however, produced a very marked and salutary change, both in the precautions adopted in loading, and in the fitting of the double bottoms, and when the inner bottom is suitably arranged to the form of the vessel, it is a source of safety as well as profit. Obviously there is much greater strength obtained, and many vessels that have been ashore have owed their safety to their double bottoms. I need not enumerate instances, as they will readily occur to many, and argument is not required to show, for experience has abundantly shown, that, if the double bottom be kept within proper limits as to height, no increased danger arises from this arrangement. When a double bottom is fitted throughout the length of both holds, and of a height greater than is absolutely necessary to secure sufficient water ballast to enable the vessel to shift from port to port, the cargo is obviously raised more than it need be, and especially with homogeneous cargoes like coal or grain; and with vessels of ordinary proportions this unduly reduces the stability. Considerations and experiences of this kind have induced builders and owners of this type of vessel to limit the height of the inner bottom, or to restrict it to the after hold and under the boilers, and thus to admit of the cargo in the main hold of the vessel being stowed lower to insure sufficient stability, whilst at the same time providing sufficient water ballast to admit of the vessel being shifted from port to port. A comparatively low double bottom, extending through both holds under the engines and boilers, doubtless combines best the properties of safety and strength with the facility for ballasting, and there is a tendency in large steamers to carry the double bottom through under the engines and boilers, as objections that were formerly raised to this are now deemed of less importance. A serious objection to double bottoms being too much reduced in height is the difficulty of examining the internal condition, as they must always admit of a man getting through, for unless they can be periodically examined deteriorations might be going on without detection, and serious results might ensue.

FIG. 14



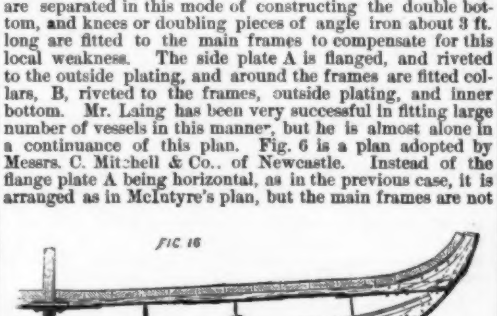
I will here glance briefly at different modes of construction that have been adopted for water ballast tanks or double bottoms. The Samuel Laing, before alluded to, was built like any ordinary vessel, and Fig. 1 shows how the tanks were arranged in the hold. The tanks are connected by pipes, and the water is let in and pumped out in the usual manner. Fig. 2 shows the arrangement of the double bottom fitted to the Rouen, being the first vessel in which a permanent double bottom entered into the structural arrangement of the vessel. The frames were separated at A, and the sides of the tank were formed by vertical plates B connected to the outside plating by the continuous angle iron C. Longitudinal girders D E F were connected to the top of the floors and on these the inner bottom G was fitted, the whole being made watertight. Fig. 3 illustrates an improvement on this, having the flange plate A arranged so as to be at right angles to the bilges. In these plans a gutter is thus formed at the sides of the vessel, thus admitting any drainage from the top of the tank to find its way into this, and thence into the engine room, or into the well at the end of the tank. This is called McIntyre's plan, from the name of Mr. John McIntyre, of the firm of Messrs. C. Palmer and

FIG. 15.



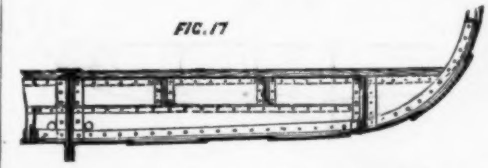
Co., who first introduced it. Fig. 4 is a plan introduced by Mr. Withy, and the builders at Hartlepool and the Tees. It is similar to McIntyre's plan with the exception of the angle irons connecting the flange plate to the outside plating being fitted on the outside, which, it is considered, offers greater facilities for caulking. Fig. 5 shows the plan first introduced by Mr. James Laing, of Sunderland. The reversed frames only are separated in this mode of constructing the double bottom, and knees or doubling pieces of angle iron about 3 ft. long are fitted to the main frames to compensate for this local weakness. The side plate A is flanged, and riveted to the outside plating, and around the frames are fitted collars, B, riveted to the frames, outside plating, and inner bottom. Mr. Laing has been very successful in fitting large number of vessels in this manner, but he is almost alone in a continuance of this plan. Fig. 6 is a plan adopted by Messrs. C. Mitchell & Co., of Newcastle. Instead of the flange plate A being horizontal, as in the previous case, it is arranged as in McIntyre's plan, but the main frames are not

FIG. 16



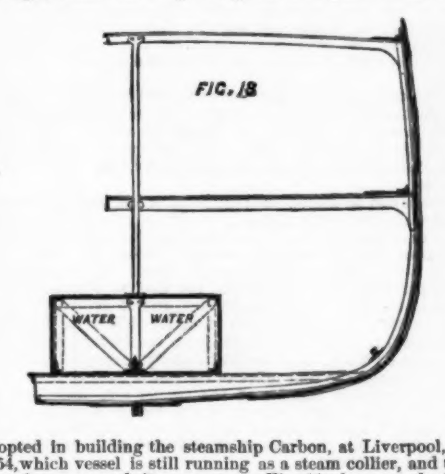
separated. The flange plate is connected to the outside plating by the angle iron B, and the angle iron collars C are fitted around the main frames. Fig. 7 shows an arrangement of beams A for receiving the inner bottom, fitted to every frame, and supported by angle irons or plates B. The flange plate is fitted against the outside plating at C, and the main and reversed frames are not cut. A continuous iron D is connected to the reversed frames, and the spaces between have pieces of wood closely fitted between the frames, and caulked. This plan was originally adopted on Tyne, but it is not now continued. Fig. 8 is a plan adopted by some builders on the north-east coast. The main and reversed frames are preserved intact, and the inner bottom is connected to the outside plating by the angle-iron A, forming collars round the main and reversed frames. The spaces between the reversed frames and plating are filled with wrought iron plugs made to the form for each separate frame. Fig. 9 illustrates a mode of constructing a deep tank extending to the height of the hold beams. This is preferred, in some instances, as it can be utilized for cargo when ballast is not required; and as the cargo can be placed lower down by this plan, the stability of the ship is increased. In some of the early ships where this plan was adopted it caused disappointment, as the importance was not sufficiently realized, when carrying a large body of water, of completely filling the compartment containing it. In early cases coamings were dispensed with, and, conse-

FIG. 17



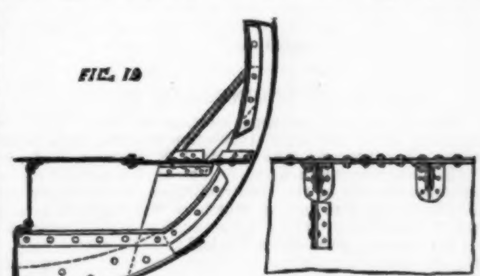
quently, that was sometimes a difficulty in completely filling it, and when the tank was not quite filled it admitted of a considerable momentum being generated when the vessel rolled or pitched. Sufficient care was likewise not always taken in making the transverse bulkheads forming the tanks sufficiently rigid by stiffeners, and it was not unusual to find these broad bulkheads stiffened with only small angle irons. These have either bulb plates, or plates and angle irons, to give sufficient rigidity. In cases where these tanks have been properly constructed—such as shown in Fig. 9 or other approved mode—the arrangement has given great satisfaction and been found most useful. The frames and reversed frames in Fig. 9 are not separated, and the spaces between are filled with blocks cast to the form, and made watertight by rust putty, and covered with cement. Great care should be observed where this form of tank is used to provide a sufficient number of manholes for ventilation, as, owing to the absence of these, the cargo in some instances has been damaged from sweating. Fig. 10 is a plan which was

FIG. 18



adopted in building the steamship Carbon, at Liverpool, in 1854, which vessel is still running as a steam collier, and the plan has anwered its purpose. Fig. 11 shows a double bottom in a steamer built in Italy, for an English firm, in 1874. A center through plate, A, is fitted with deep floors connected to the same. The inner bottom is fitted on the floors, and the space between is divided by intercostal plates B. This vessel is employed in general trade, and the arrangement has given satisfaction to the owners. Fig. 12 is somewhat similar. This vessel was built in 1876 by Messrs. Austin and Hunter, Sunderland, and is, it is considered, a very satisfactory as well as novel mode of construction. The longitudinal webs are about 4 ft. apart, and there are solid transverse intercostal floor plates 14 ft. 8 in., at eight frame spaces apart, and intermediate between these, at four spaces of frames, are bracket plates, as shown, B B B; intermediate between these again are angle iron stiffeners to the longitudinal girders and inner bottom C C C, and the frames extend across the ship at every 22 in. apart—the ordinary room and space for a vessel of her size. Such a mode of construction, whilst providing for the carrying of water ballast, enables a strong bottom to be formed with less weight of iron, and, it is said, less cost. Figs. 13, 14, 15,

FIG. 19



16, 17, 18, and 19 show plans which have been adopted at various times, but most of which have not been repeated. Other plans have been adopted, but time or space will not admit of a description of all of them.

I cannot conclude without drawing to a novel adaptation of water ballast to sailing vessels. Several of these vessels, as illustrated in Fig. 20, have been designed and built by Mr. Bone, formerly surveyor to Lloyd's Register, late manager for Messrs. Cole Brothers, Newcastle, and now managing director of the Tyne Shipbuilding Company. These sailing vessels are designed to carry a cargo of coals which will just fill them. They take coals to Almeria or Valencia, or any of the Spanish ports, and whilst discharging take in water ballast, and proceed to Pomaron or Huelva for ore, which is brought to the Tyne, Hull, London, or Aberdeen. They have provision for 150 tons of water ballast, which, on arrival at the port of loading, is pumped out by the crew with

a 6 in. Downton pump. The voyage occupies about two months, on which, in addition to the saving from detention, there is a gain of £40 each voyage from not having to purchase or take in dry ballast. These vessels have answered well, and have been enabled to compete successfully with steamers. I have seen other attempts to introduce the advantages of water ballast to sailing ships, some of which scarcely deserve such high recognition. Whether provi-

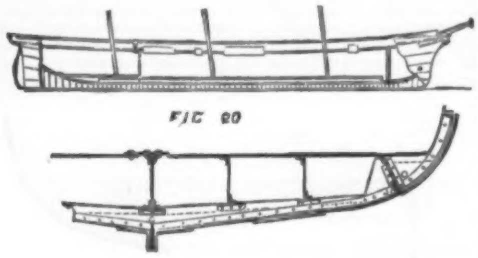


FIG 20

sion and arrangement for water ballast will be extended to larger sailing ships I cannot venture to predict; but in view of the early attempts to introduce it in steamers, and the vast importance it now assumes in this description of property, it would not be surprising if we were to experience a further development to some extent in this direction. However this may be, my chief object has been in this paper to place before you some of the plans that have been adopted, and the expedients that have been resorted to, together with the circumstances that have given rise to them, in connection with this subject of water ballast.

THE SUTRO TUNNEL.

A correspondent of the London *Mining Journal*, who calls himself "An Engineer," gives the following rather discouraging view of the value of the Sutro Tunnel.

The tunnel will be 20,000 ft. long, and will cost £720,000. It will tap the Comstock lode at 1,800 ft. from the surface; but as the various workings on this lode occupy a length of more than three miles the tunnel will be of no use to them until they are connected with it. In new sinkings machinery must be erected in the first place, and the same machinery will haul the ore to the surface, and the water also.

The minerals and water from the workings below the level of the tunnel (and the principal mines are all below 1,800 ft.) will have to be raised up to that level, and as in all probability the engines for raising it will be erected on the surface the extra 1,800 ft. would not add much to the cost of raising the ore.

Coals can be drawn 300 fms. at 2d. a ton, and suppose fuel and wages to be ten times it would only be 20d. per ton or less than half-a-dollar; but as there will be machinery needed to draw the ore from the workings below the tunnel there will not be much saving on this head. As to ventilation any practical man knows that the shorter distance the air has to travel the less is the friction, and of course, the easier the ventilation; and if a pair of shafts of 15 or 20 ft. diameter, 1,800 ft. deep, were sunk from the surface, and a 30-ft. fan put on them, there would be vastly more air than would pass through the four miles of the Sutro Tunnel.

The probable benefits of the tunnel are, therefore, narrowed down to the drainage of the lode to a depth of 1,000 ft., and if this be all we have the cost of draining dearly bought. Thus the interest of £720,000 at 10 per cent. per annum is £72,000.

I understand the feeding raised by all the engines upon the Comstock lode is about 1,500 gallons per minute. If, therefore the advantage of the tunnel be confined to the drainage only, we have the cost of raising 1,500 gallons per minute 1,800 ft. high, £72,000 per annum. I rather think some of our Cornish engineers would do it for less.

MACHINERY FOR BORING ROCK.

This improvement, by Shaw and Clark, of Ovenden, near Halifax, England, consists of a cylinder and piston rod with two pistons. Steam, air, or other elastic fluid is introduced into the middle of the cylinder, and acting on one or other of the pistons, closes the exhaust, and forces the steam or air from one piston to the other piston. This is effected by one or other of the pistons coming into contact with a slide valve, which at the proper time closes the required port or ports, leaving other port or ports open. The drill, being fixed or attached to one end of the piston rod, is automatically fed into the rock at every blow of the piston by means of a small cylinder fixed to the side of the above-named cylinder, and so arranged that steam or air will pass from the large or first-named cylinder to the small cylinder, and act upon suitably arranged catches and wheels.

LIVERPOOL ENGINEERING SOCIETY.

This Society held its usual meeting on Wednesday evening, Oct. 10, at the Royal Institution, the President in the chair. A paper was read by Mr. I. E. Clanchy, B. A., on "Civil Engineering in Brazil." The author gave a very interesting account of the construction of the San Paulo and Rio de Janeiro Railway, on which he was engaged as sub-resident engineer. Owing to the peculiar physical character of the country, great difficulties had to be overcome, both as regards surveying the line (no maps and very seldom roads being available), and afterwards in the construction. As is usual in Brazil, the work was let to a number of small contractors who gave endless trouble by their craftiness and ignorance. Young engineers were urged to make themselves acquainted with the properties and qualities of limes and clays, as in an undeveloped country they were called upon to decide what clay was suitable for brick and what worthless, and similarly in regard to the local stone used for making lime. In Brazil the contractors tried to use a stone called *saiba*, very much resembling limestone in appearance, but possessing none of its properties, and which was, of course, utterly useless for mortar. The railways in Brazil are laid to the 5 ft. 3 in. Irish gauge, and the meter gauge—the latter being most in favor at present. The San Paulo and Rio Railway was constructed to this gauge with rails of the Vignoles pattern weighing about 45 lbs. per yard. Steep gradients had to be adopted on some portions of the line, but nothing like the Santos and San Paulo Railway, which rises 2,600 feet in about 5 miles. This line is worked by stationary engines placed at intervals, and the traffic is so arranged that descending trains assist those ascending. In case of accident a novel brake is provided which grips the rails and instantly arrests the motion of the trains. Mr. Clanchy referred to the absence of good roads in Brazil as checking the development of the railway system; for without arteries and ramifications in the shape of roads extending into the country around, a railway is merely an expensive luxury. In conclusion, details of the cost and mode of construction were given, together with much valuable information as to carrying out works of this class abroad.

After reading the paper, Mr. Clanchy received a hearty vote of thanks for the interesting manner in which he had brought the subject before the meeting.

W. Wilkinson, Hon. Sec.

Dockyard, Liverpool.

ON LAUNCHING THE IRONCLADS KAISER AND DEUTSCHLAND, AND OTHER LARGE SHIPS.*

By Mr. D. A. Samuda, M.P., Vice-President.

The launching of a large and costly vessel is a serious matter. There is scarcely any operation throughout the construction of a vessel likely to cause the builder more anxiety or to result in more serious consequences if from any cause a failure should attend his efforts to insure a successful launch. If reference is made to the cases of important failures that one man can recollect during the last twelve or fourteen years—omitting altogether the failure of launching the Great Eastern as a vessel both exceptional in itself, and also in the mode adopted of launching—we should have to record that of Her Majesty's frigate Cæsar, at Pembroke, the iron-clad frigate Northumberland, and the Brazilian iron-clad Independencia, on the Thames. The cost of failure in these three cases could not have been very short of £300,000, and the matter therefore appears to be of sufficient importance to place on record, for the benefit of the present and future shipbuilders, the precautions that have been taken by my own firm, and which have been based on the result of many years' experience, and possess the advantage of having been uniformly successful. The most convenient course to adopt, I think, will be to describe accurately the course pursued in some special case, and to draw attention to any special conditions that should be carefully borne in mind in similar cases, and I have therefore selected the case of two of the largest vessels I have built, as in all cases reducing the proportions and precautions for smaller craft will be more easily and more safely accomplished than by working up to larger and heavier vessels. I propose therefore to describe arrangements employed in constructing the ships and carrying out the launch of the two German ironclad frigates, Kaiser and Deutschland. The principal dimensions of each were: length, 285 ft.; beam, 63 ft.; gross displacement—when fully equipped and engined—7,400 tons.

Preparation of Slip.—The slip is formed of no less than 400 piles of Dantzic fir, each 16 in. square and about 30 ft. to 40 ft. long. These are arranged in traverse rows of seven piles in each row; spaced with intervals of 7 ft. for the entire length of the slip. These piles are arranged generally as shown in the engraving, page 170, as follows:—Two in the middle line to support the keel of vessel; two approximately under each launch, and one beyond alternately on each side. In addition, the number of piles is increased on the lower portion of the slip beyond that on which the vessel is built, and over which it has to travel before finally leaving the end of the sliding planks. Cross baulks of Dantzic fir, 16 in. square, are worked on the top of each row of (seven) piles and tenanted on the top of them. Additional piles are also driven under the fore-foot of the vessel to support the extra weight of the overhanging bow. The piles are in every case driven down to the gravel, generally about 30 ft. to 35 ft. below the surface of the ground, for which purpose a pile-engine and a 20 cwt. monkey is used, and when this weight falling through 26 ft. fails to drive the pile more than half an inch, the required solidity is considered to have been attained. Longitudinal baulks are worked on the fore end, where the piles project much above the ground; and aft where from the rise and fall of the tide, the ground is shifting 50 tons of chalk were also placed round about the ship to obviate the action of the tide. On the top of the cross baulks, shorter baulks are fastened, also of Dantzic fir, and these are surmounted with hard wood blocks on which the keel of the vessel rests.

Buttresses—In addition to the solid foundation thus obtained, it is a usual practice to build up at least six buttresses, three on each side—in this case four on each side were adopted—under the bilges of the vessel. These buttresses are formed of baulks of timber about 16 in. square and 8 ft. long, and are laid alternately lengthwise and transversely, forming a sold pedestal 8 ft. square, and reaching from the ground to the underside of the bilge, and thus relieving a large portion of the weight of the ship from the blocks under the keel in the center line. As a further precaution, blocking is used between the ground and the transverse or cross blocks, so as to distribute the weight more effectually from the center to the side piles. Though the cross baulks were of Dantzic fir, as here described, I would remark that it would have been a great improvement to have used hard wood instead. While building the vessel the entire weight—except to the extent relieved by the buttresses and shores—clearly is taken by the logs over the center piles, and the effect on the cross baulks was to press them so seriously that they actually forced in the fibre of the wood where tenanted to the center piles, and caused a deflection of the cross baulks to the extent of $\frac{3}{4}$ in.—a result due to the softness of the fir, which probably hard wood might have resisted.

Inclination.—The inclination of the slip while building was $\frac{9}{16}$ in. per foot, and the blocks were kept a sufficient height to allow convenient room for working under the vessel, and for giving additional inclination for launching. If this is not attended to when the keel is laid, great difficulty and risk may occur when the launch has to be prepared. The launching ways are laid with a camber of 8 in. in their length, the line being carefully set off to form the arc of a circle; the inclination at the top is $\frac{5}{8}$ in. per foot, increasing lower down in accordance with the camber.

Launching Ways.—These are of rock elm, 4 in. thick, bolted together and to the cross baulks on the top of the piles and supported by blocking up between the piles, wherever they are sufficiently out of the ground to enable this to be done. The ways are 3 ft. 8 in. wide, with a ribbon of oak 8 in. by 4 in., increased at the fore-end to 11 in, by 11 in. to receive the heel of the dog-shores on the outer side of each.

Bilge Logs and Launch.—The bilge logs are of oak, each 260 ft. long by 3 ft. 1 in. wide, and are each composed of five lengths attached together by chains. The total area of the bilge logs on both sides was 1,600 ft.—the launching weight of the Kaiser was 3,500 tons—thus giving a weight of 2·15 tons on each superficial foot of bilge-log surface. The Deutschland weight as launched was something less, viz., 3,000 tons, giving a weight of 2 tons—nearly—on each foot of bilge-log surface. The greatest weight that I find by practice may safely be allowed is 3 tons of weight to each foot of greased bilge-log surface; anything within this may be considered safe. On the top of the bilge logs is worked the stopping up, which is composed of Dantzic fir timber, carefully fitted to the ship with poppets at fore-and-aft ends. The top of the poppets are lined with iron and fitted with iron forgings against the lands of the skin plating and secured by two iron bars, each $3\frac{1}{2}$ in. diameter, lashed together at both ends by chains passing under the fore-foot of the vessel—as shown in the drawing. The fore-ends of the launching logs are also securely lashed together by chains and ring bolts, having fore-locks for disengaging after the launch, which is done from the deck of the ship. By this arrangement the fore poppets and launch are maintained in their places, and prevented from spreading out when the extra strain comes on the fore-end of the launch at the time when the stern is lifting, and are easily and instantaneously disengaged and set free when the launch has been effected.

Sustaining Power of Slip.—The sustaining power of each pile driven under the conditions before named may be taken, approximately, to be thirty tons—it is really more. The slip, therefore, under the entire ship—280 ft. long—would support no less than 8,400 tons; but during the building of the ship and before the launch is laid, the weight would have to be carried on the center piles only, and then 2,400 tons only could be carried—showing that, with all these preparations, there would still be 1,000 tons weight to be carried by the buttresses, shores, and the distribution of weight—by the means previously noted—from the center to the side piles.

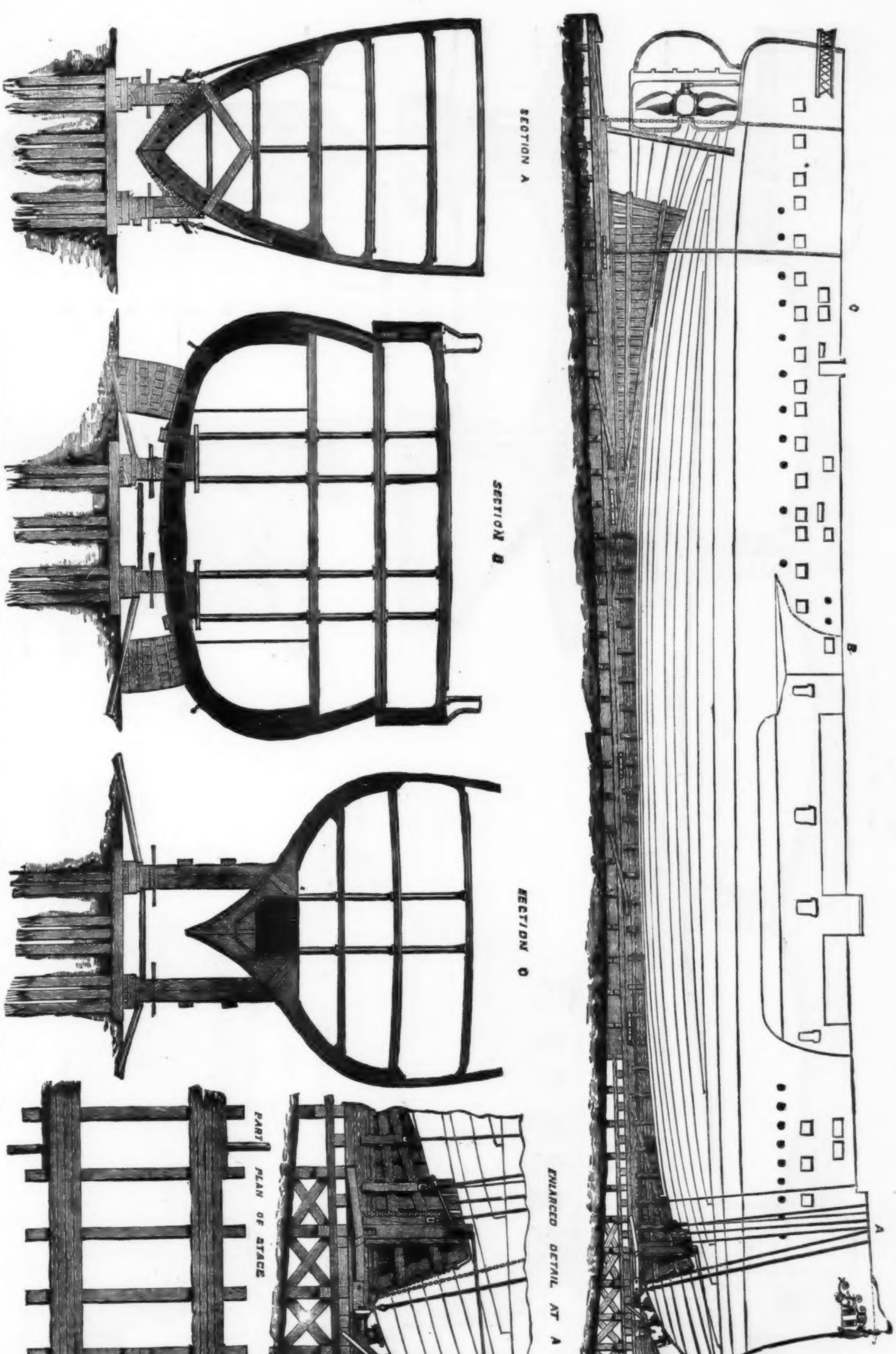
Shoring up inside the Ship.—A tier of shores between the inner and outer bottom is placed over each launch, with shores above the inner bottom up to each deck above; particular care is taken to shore up strongly over the foremost poppet to resist the extra strain that part receives when the vessel is partly in the water. The vessel received no damage or straining whatever in launching, not a rivet head fell off nor did the slightest sign of injury show itself, and the same may be said of the numerous vessels launched during the last twenty-five years from the same works, and in which similar care—according to the size of the vessel—had been bestowed on the arrangements and carrying out of the launch. The small change of form of vessel before and after launching was further most satisfactorily proved by ascertaining that no caulking of water-tight compartments of the double bottom was disturbed; the whole of the compartments—thirty-two in number—were tested by filling with water under pressure while the vessel was on the slip, and a repetition of the water testing was again made after launching, and every compartment found to be absolutely tight.

Launching.—After the whole of the launch, stopping up, poppets, &c., have been accurately fitted to the vessel, and about three weeks previous to the launch, the launch is turned out and the ways coated with hot tallow and soft soap, then replaced and fixed. On the day of launching oil is forced between the bilge logs and the launching ways through oil holes provided for the purpose, the quantities used being as follows, viz., for the entire operation of launching:—Tallow, 4 tons 6 cwt.; soft soap, 5 cwt.; oil, 55 gallons. On the morning of launching, the vessel was set up by driving in wood wedges between the bilge logs and stopping up; and when the weight is so far taken on the launch, the blocks under the keel, and the bilge blocks and shores are gradually removed, beginning from aft, but leaving from ten to twenty blocks, according to circumstances, under the fore foot of the vessel until the dog shores are down. Cleats at the after part of the launch are provided to assist the dog-shores till near the time of launching, when they are gradually and carefully removed. The dog-shores are removed by the fall of the weights—one on each side of 6 cwt., acting on its own dog-shore and suspended over them by a rope passing round the stem. This rope is cut by the lady who launches the vessel, thus releasing the two weights at the same instant and insuring the dog-shores being removed simultaneously.

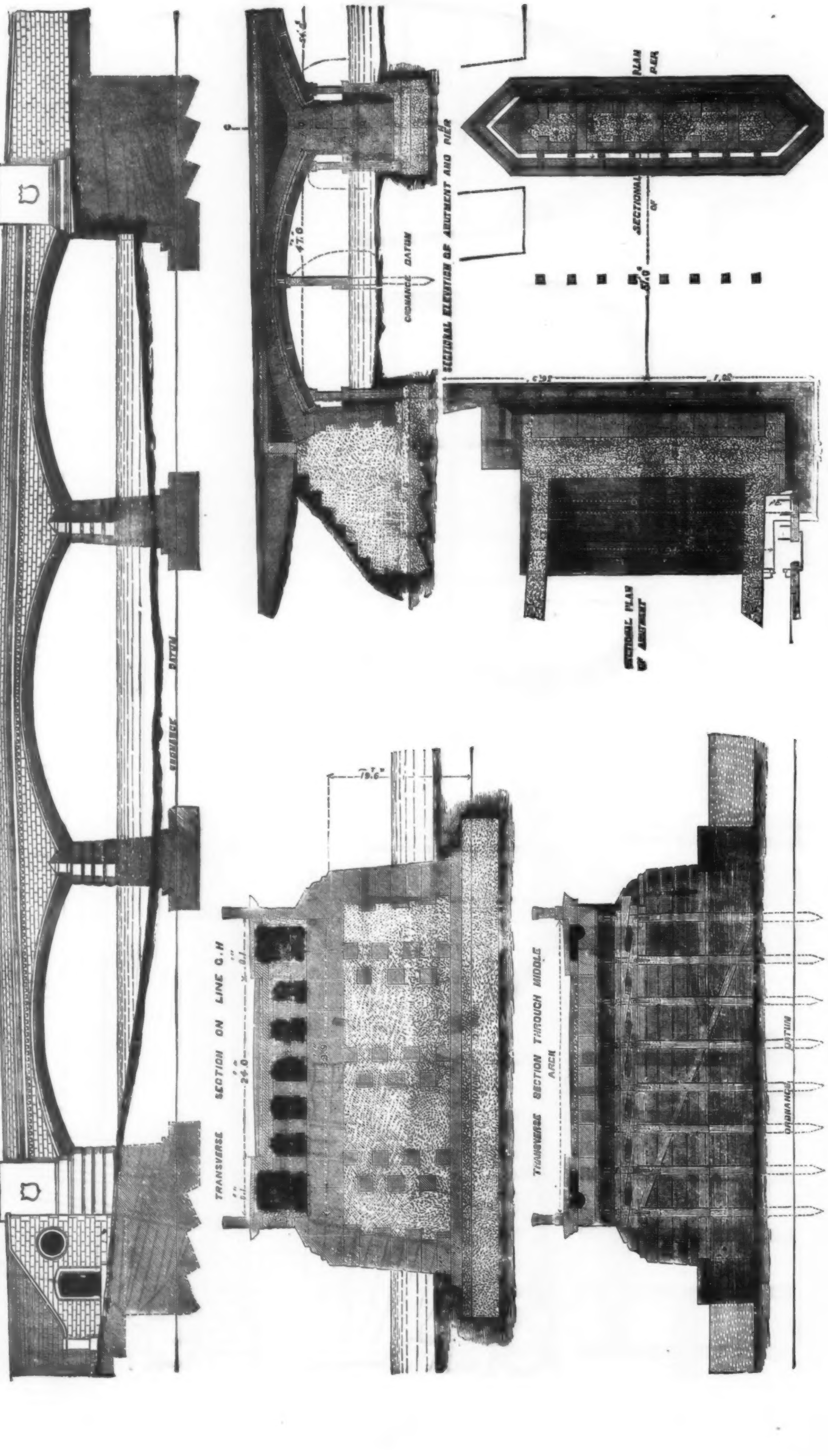
Hydraulic Ram for Starting Vessels.—One 60-ton ram was fixed at the end of each bilge-log, and one 100-ton, one 60 ton, and one 40-ton ram under the fore-foot of vessel, besides a large tackle on each side led to a double-purchase crab. These were provided in case of need to start the vessel, but were not required, as she began to move as soon as the dog-shores were down, tripping most of the blocks left under the fore-foot.

Check Rope.—A hawser was fixed to the stern of the vessel and attached to a chain cable and anchor carried some distance up the stream, and so arranged in length and position as to cant the stern of the vessel up the river as soon as she became clear of the slip, and so prevent the danger of the vessel running on shore on the opposite side of the river. By this means the vessel is also brought into a suitable position to be laid hold of by a tug steamer that is kept in readiness for that purpose; and when so attached to the tow-rope of the steamer, other tugs are employed to draw out the launch and entirely sweep and clear away whatever fragments of it may still be left adhering to the hull. In conclusion, I would wish to be allowed to express a hope to any with less experience than myself that no inducement, however great, should be accepted as sufficient for foregoing what to many may seem the unnecessary precautions and the great expense that must result from following the plan of operations here described, after, of course, making suitable variations from it to meet the demands of each special case. I know in these times of competition how anxious all—and especially young firms—are to save every expense that can possibly be avoided; but it is only those who have seen the misery that failure in so important an effort in a man's life involves, and the financial ruin that results from trusting to luck instead of to well-cultivated arrangements and caution, that can properly estimate the advantages of insuring success at any cost and care—and this induces me to take the unusual course in a paper of this sort, of urging in the interest of all engaged in the important operation of building and launching vessels of the size and cost that they have now reached, to think no trouble or expense wasted that will insure the success of the important accomplishment of their work.

* Institution of Naval Architects.



LAUNCHING SLIP FOR THE IRONCLADS KAISER AND DEUTSCHLAND.



NEW BRIDGE OVER THE MEDWAY AT MAIDSTONE. SIR JOSEPH BAZALGETTE, M.I.C.E., ENGINEER.

NEW BRIDGE OVER THE MEDWAY, AT MAIDSTONE.

A NEW bridge is to be constructed across the Medway at Maidstone, from the designs of Sir Joseph Bazalgette. The estimated cost is £32,000. The bridge is to be of stone. Some of the ratepayers, however, are in favor of an iron bridge; claim for it that it would be cheaper, more elegant, and could be erected in one span, and ask why all the modern bridges, such as those of Westminster, Blackfriars, &c., are built of iron if stone is preferable. To this the Local Board reply that iron bridges require constant painting, are less durable, and are only adopted in London because "the constructors, being limited in funds, have to use, not the best, but the cheapest materials."

The specification is very long and elaborate. We give only so much of it as is necessary to render clear the nature of the work to be done.

Foundations.—The ground for the foundations is to be excavated to the depth shown in the drawings, or to such greater or less depth as the engineer shall direct. The sides of the excavations are to be properly secured, so as to prevent the ground caving in, and they are to be kept free from water. The foundations for the piers and abutments are to consist of beds of concrete 5ft. in thickness, or of such greater or less thickness as the engineer shall direct, and of the dimensions shown in the drawings. The concrete in these foundations is to be composed and manufactured of the materials and in the manner hereinafter specified as Concrete No. 1. In depositing the concrete in these foundations great care is to be taken that the cement is not carried away by pumping, currents, or otherwise, and shoots, or such other appliances as may be required, shall, if necessary, be used; but should the concrete become impoverished by the washing away of any of the cement, it must be replaced by fresh concrete at the contractor's expense.

Coffer Dams.—Vertical posts of sound Memel timber, 12in. square, are to be embedded in the concrete of the foundations in the positions shown in the drawings. Two horizontal wallings, 12in. by 16in., are to be securely bolted to these posts, one at the level of the top of the concrete, and one at 12ft. 6in. above ordnance datum, and the space between these wallings is to be filled with planking of the thickness shown in the drawings, the edges of the planks being sawn true, so as to form a tight joint. Should leakage occur at any of the joints it is to be stopped by the insertion of fine wedges of pine, or by caulking, so as to render the dam perfectly water tight. Each dam is to be provided with a sluice, not less in area than one square foot, placed at the level of the lowest part of the bed of the river, with proper gear for opening and closing the same, so as to enable the dam to be filled gradually at times of floods or otherwise. The coffer dams are to be maintained at all times perfectly dry during the construction of the abutments and piers. Upon the removal of the coffer dams the vertical posts shall be sawn off at the level of the top of the lower walling, the space between the lower walling and the footings of the piers and abutments having been first filled with Concrete No. 1.

Abutments.—The abutments are to be constructed of granite ashlar facing, backed with concrete, composed and manufactured of the materials and in the manner hereinafter specified as Concrete No. 2, and are to be of the form and dimensions shown in the drawings. The masonry is to be composed of horizontal courses of headers and stretchers, alternately, the headers not to be less than 3ft. in length and 2ft. in width, and the stretchers not less than 4ft. 6in. in length and 1ft. 9in in width. The vertical height of the courses to be as shown in the drawings. The backing to be of Concrete No. 2, brought up with the masonry course by course. The whole of the exterior stone is to be smooth and fine hammer-dressed on the face, the quality of the work being equal and similar to that of the granite facing of the Victoria Embankment. The horizontal beds are to be fine dressed and rusticated 2in. each way, but the vertical joints are to be plain and perfectly straight and fine dressed for at least 15in. inward; the remainder of the stone to preserve its full dimensions, and to be fair picked and straight between. The whole of the masonry is to be set flush in beds of mortar of the materials and quality hereinafter specified as Mortar No. 1, and properly grouted. The whole of the ashlar masonry is to be composed of the best close granite, to be approved by the engineer. The several stones to be worked of the form and dimensions shown in the drawings, the faces, beds, and joints being true and out of winding. Grout nicks to be cut in all vertical joints of the ashlar work, according to the directions of the engineer: and slate dowels or joggles, 2in. square and 4in. in length, to be used where and when considered necessary by the engineer. The moulded course is to be fine hammer-dressed to the true form shown in the drawings. Four bronze shields, two having the borough and two the county arms, of a design to be approved by the engineer, shall be fixed on the face of the abutments as shown.

Piers.—The piers are to be constructed of ashlar masonry backed with concretes in all respects similar to that already specified for the abutments, and to be of the form and dimensions shown in the drawings. Every alternate header is to be carried through the pier from face to face, as shown in the drawings, and the cut-waters are to be constructed of stones of the form and dimensions shown, and secured by slate joggles, as directed by the engineer. The abutments and piers are to be carried up together so that the whole of the three arches may be carried over simultaneously. A drain of stoneware pipes, 6in. in diameter, is to be formed in each pier and abutment in the positions shown in the drawings, the joints being made with Portland cement, care being taken that no cement shall be left projecting in the interior of the pipe. Circular holes, 6in. in diameter, are to be cut through the ashlar granite facing at the level shown to form the outlets to these drains.

Centers.—The centers are to consist of eight ribs of wrought iron, of the form and dimensions shown in the drawing. These ribs are to be supported upon transverse sills of sound elm timber, formed as toothed wedges, as shown in the drawing. The vertical posts of the coffer dams are to be carried up to the height shown in the drawing, and in each side arch a row of piles is to be driven, and in the middle arch two rows of piles, which are to be braced with diagonal braces, and surmounted by longitudinal sills, as shown in the drawings. Upon these sills wedges of sound elm are to be placed, corresponding in form and inclination to the elm sills under the wrought iron ribs. These wedge pieces are to be cased on their upper and lower bearing surfaces with fine sheet copper, one tenth of an inch in thickness, and are to be well greased previous to being put in place. Wedge pieces of elm, accurately fitted, are to be introduced between the ends of the wrought iron ribs and the piers, so as to form skewbacks for the ribs, and the wedge pieces are to be supported by vertical timbers, 12in. by 9in., as shown in the drawings. Longitudinal timbers, 9in. wide and 6in. thick, are to be securely bolted down to the upper flanges of the wrought iron ribs, the heads of the bolts being let flush into the timber, and the covering of the centres for carrying the arch stones is to be of good sound fir, half timber, 6in. in thickness, to be carefully laid, properly leveled, and adzed off to the true curvature of the respective arches. On the removal of the centres the piles in the middle of the arches may be drawn, but those on the west side of the centre arch shall be cut off at the same level as the vertical posts of the coffer dam. Should the engineer within three months after the completion of the bridge give the contractor notice to that effect, the wrought iron ribs shall be delivered in good condition at any point in the Medway designated by the engineer within ten miles of Maidstone.

Arches.—The arches are flat segments of the form and dimensions shown in the drawings, and together with the skewbacks are to be of granite. The skewbacks both of the abutments and piers are to be composed of stones of the form and dimensions shown, not less than 4ft. upon their beds, measuring across the axis of the bridge. When set they are to form a true, even plane, the full depth of the arch stones, truly perpendicular to the tangent to the intrados of the arch at its springing. The vertical thickness of the voussoirs or arch stones is to be as shown in the respective drawings, and they are not to be less than 3ft. in width, measuring lengthways over the bridge, or less than 4ft. measuring across the bridge, and none of them are to overlap the stones in the adjoining courses less than 13 in. The arch stones are all to be dressed perfectly smooth and true, according to their respective positions, the soffit being truly formed to the curvature of the intrados, and the sides worked so that a parallel joint shall be left between each course of arch stones three-eighths of an inch in thickness, and truly perpendicular to the tangent to the intrados of the arch at that point. In setting the stones vertical strips of lead, three-eighths of an inch in thickness, 2in. in width, and the whole depth of the stones in length, are to be introduced—one at a distance of 6in. from each end of each stone; and so soon as each course has been completed the joints shall be grouted with neat Portland cement of such a consistency as to fill perfectly the whole of the joints. The extrados of the arches are to be rough hammer-dressed. The whole of the joints of the arch stones are to be fine dressed over their whole surface, without any deficiency whatever. The outer row of arch stones forming the face of the arch are to be finished with an architrave moulding of the form shown, and the extrados smooth dressed for a sufficient depth to receive the face stones of the outer spandril walls. The whole of the three arches are to be carried over together, in such a manner that no arch shall at any time be more than one course in advance of the others.

Outer Spandril Walls, Cornice and Parapet.—The caps over the cutwaters of the piers are to be composed of granite, fine hammer-dressed to the form shown on the drawings. The outside spandril walls between the extrados of the arches and the cornice are to be faced with Kentish rag stone, backed with Concrete No. 2, of the thickness shown on the drawings. The Kentish rag stone is to be of the very best quality, to be carefully selected, and to be approved by the engineer, and great care is to be taken that the stone is worked and set with reference to its natural bed. The Kentish rag stone facing is to be built in horizontal courses of the respective heights shown on the drawings, to average 7in. in thickness, and to have not less than four bond stones tailing at least 7in. beyond the adjoining stones in each superficial yard of work. The whole of the rag stones are to be nobbled truly square, free from broken corners, so as to insure an appearance of perfect squareness in the vertical and horizontal joints without the assistance of pointing; and with which object such stones as have been imperfectly nobbled at the quarries, or injured by their carriage to the works, shall, if directed by the engineer, be renobbled on the ground. All the stones meeting the extrados of the arches are to be truly nobbled to fit the same. The whole of the stones to be bedded solid in Mortar No. 2, to be well backed up with scabels or spawls, and all joints to be thoroughly flushed up with mortar, and the backing of concrete carried up course by course as the work proceeds. The stones to be laid with a close sunk joint, to be struck as the work proceeds. The cornice, plinth, and coping are to be of granite, finely dressed to the form and dimensions shown on the drawings, to be set with the thinnest points possible, and the coping stones to be secured with a slate joggle at each joint $1\frac{1}{2}$in. square and 3in. in length. The parapet between the plinth and coping to be of Kentish rag stone similar in every respect to that above described, and having six through stones in every superficial yard of work.

Inner Spandril Walls and Covering.—Upon the completion of the arches the whole surface of the extrados and skewbacks shall be covered with a perfect coat of asphalte of the best quality, to be laid in one perfect and continuous sheet 3in. in thickness over the entire surface, and turned up at 2in. in height against the outer spandril walls. The surface over the skewbacks is to be made up with fine concrete, so as to incline in every direction, with a current of $\frac{1}{2}$in. in 10ft. towards the drain pipes previously specified to be built into the piers and abutments. Upon the completion of the asphalte the inner spandril walls shall be built of the dimensions and in the position shown, with sound, hard, and well burnt square stock bricks, laid in mortar, No. 2. The bricks are to be used in a humid state, and the mortar is to be used sufficiently thin in the interior of the work to enable the joints to be flushed full without grouting. The bricks in every course are to be well bonded, and the several courses are to cross joint so as to form the most sound and perfect work. The beds and joints in every course are to be kept as thin as possible, consistently with sound work. Each wall is to be capped with a course of Bradford foundation landings, 9in. in thickness, and 3ft. in width, bedded in Mortar No. 2, so as to project equally on each side of the spandril walls. The whole surface over the inner spandril walls is then to be covered with a floor of Bradford foundation landings, 9in. in thickness, bedded in Mortar No. 2, and so laid that the longitudinal joints shall coincide with the centres of the spandril walls. The outer margins of this floor are to correspond with outer sides of the first and last of the inner spandril walls, as shown on the drawings. Those last mentioned spandril walls are then to be carried up to receive the inner edge of the foot-paving, which shall consist of the best granite paving, 7in. thick, picked true on the upper surface, joints and edges, and on so much of the beds as rest upon the cornice course and the spandril walls. These stones are to be in one length of 8ft. 1in., and are to be laid with a fall of 2in. towards the roadway, and to be solidly bedded in Mortar No. 2. The joints are to be secured with cement joggles, as shown.

Wing Walls and Approaches.—The wing walls are to be constructed with Concrete No. 2, faced with Kentish rag stone. They are to be of the form and dimensions shown on the drawings, with the true curvature on plan and batter there shown. The Kentish rag stone facing is to be in every respect similar to that already specified for the facing of the outer spandril walls. The string course and coping are to be of granite, fine hammer dressed to the form shown on the drawings, and the latter being secured with slate dowels at the joints in all respects similar to the coping over the bridge already specified. The caps at the termination of the wing walls are to be of granite, fine hammer dressed, of the form and dimensions shown, and each to consist of one stone. At the Borough end and on the lower side of the bridge a flight of steps is to be constructed in the position and of the dimensions shown in the drawings, and the space beneath the same is to be formed into a urinal. Beyond the terminal piers of the walls at the Maidstone end of the bridge, retaining walls of Concrete No. 2, faced with Kentish rag stone in all respects similar to the wing walls, are to be constructed of the form and dimensions and in the positions shown on the drawing. These walls are to be capped with a granite curb 12in. by 9in., set in mortar No. 2, no stone to be less than 4ft. in length, and slate dowels $1\frac{1}{2}$in. square, and 3in. in length, being introduced at each joint. These retaining walls are to be surmounted by an ornamental cast iron railing 3ft. 6in. in height, of a pattern to be approved by the engineer, and weighing not less than 56 lb. to each foot in length. This railing is to be firmly fixed to the granite curb with lead properly and thoroughly caulked. The filling of the approaches is to be composed of dry hard material, to be approved by the engineer, and is to be carefully punned for a thickness of a yard behind the walls and abutments; and the remaining portion is to be formed in layers not exceeding 18in., each layer to be consolidated by rolling before the next is deposited.

Roadway and Footpaths.—The filling having been brought up to the formation level, and consolidated to the satisfaction of the engineer, the roadway shall be formed of broken granite, no stone exceeding 2in. in greatest dimension. Over the entire surface of the Bradford foundation landings covering the bridge, a bed of Concrete No. 2 shall be spread 6in. in thickness in the middle, and $4\frac{1}{2}$in. at the sides: the upper side being finished to a true and smooth surface. The thickness of broken granite over this concrete shall be 9in. in the middle, and $7\frac{1}{2}$in. at the sides, thus giving to the surface of the road a camber of 3in. in its cross section. Over the other portions of the road to the extent shown upon the plan, the roadway is to be formed with a layer of 12in. of broken granite, the surface being finished with such curvature as the engineer shall direct. A small quantity of chalk is to be mixed with the broken granite at the surface, and the whole is to be thoroughly consolidated by rolling. In continuation of the footpaths over the bridge, footpaths of the best Yorkshire landings, 4in. thick, are to be laid in courses not less than 2ft. 3in. wide, and no stone to contain less than four superficial feet; they are to be fair tooled on their upper beds, and squared on their lower beds, the joints to be properly dressed and set in mortar composed of one part of blue lias lime to three parts of sand. The footpaths on their outer side are to be bordered by curb stones of the best granite, not less than 12in. wide, 9in. thick, and 4ft. in length, to break bond well with the landings, and to be properly fitted to the paving. The landings and curb to be laid and solidly bedded in the best manner, with proper rounded stones at the corners of the pavement. There is to be a paved gutter on each side of the road, to be laid with three courses of the best granite sets, $4\frac{1}{2}$in. wide, and $7\frac{1}{2}$in. in depth, truly laid and properly grouted; and crossings in continuation of the footpaths are to be laid across the roadway in the positions and of the widths shown on the plan, to be composed of granite sets of the same dimensions and similarly laid. The existing footpath on the north side of the road leading to the Town Wharf is to be relaid of a reduced width, to the extent shown on the plan.

Removal of existing Bridge.—The contract sum is to include the expense of pulling down and removing the existing bridge, together with the foundations of the eastern abutment and the piers, so that no hard material shall be left in the bed of the river above the level of 3ft. Ordnance datum.—*Engineer.*

THE TAY BRIDGE.

ONE of the most notable triumphs of modern engineering is achieved in the completion of the construction of the Tay Bridge, which carries the North British Railway across the Frith of Forth. The project has repeatedly been brought forward during the past thirty years, but it was not till 1871 that the work was commenced. The history of its execution, which we take from the *Scotsman*, is interesting as a record of engineering difficulties overcome by persistent perseverance and high professional attainments. The plans were originally prepared by Mr. Bouch, C.E.

What with the novel and extensive character of the undertaking, and the arduous conditions under which it had to be carried out, the bridge has taken longer to build than was at first anticipated. In the outset the operations were necessarily to a certain extent of a tentative character. When one difficulty after another had been overcome, steady and rapid progress began to be made; but still the ever-varying contingencies of wind and weather remained to be dealt with; and we believe that a detailed account of the practical problems which arose at various stages, and the manner in which, under the superintendence of Mr. A. Grothe, the resident engineer, professional skill was brought to bear on their solution, would form a most interesting chapter in the history of modern engineering. At the point selected, about a mile and a half above Newport, the river has a breadth of nearly two miles, its depth at high water of spring tides attaining a maximum of 45 ft., and the velocity of its current ranging up to 5 knots an hour.

To bridge this formidable stretch of water the engineer had planned a structure of 85 spans, which, as now realized in brick and iron, presents a noteworthy example of the purpose-like adaptation of means to ends. The spans vary in width from 67 ft. to 245 ft., those of the largest size, to the number of thirteen, being placed over the navigable part of the river. In this central section, where it is necessary to provide for the passage of such shipping as frequents the ports of Newburgh and Perth, the bridge has a clear height of 88 ft. above high-water mark, from which it slopes down to the Fife side with a gradient of 1 in 356, and towards the Dundee end, where it takes a curve to the eastward, in order the more conveniently to join the land line, with a gradient of 1 in 73.

THE MANAWATU GORGE BRIDGE, NEW ZEALAND.

WE give a sketch of the Manawatu Gorge Bridge and a scene on the Manawatu river, which divides the provinces of Napier and Wellington, New Zealand. The Gorge Bridge is the connecting link between the provinces named, and was opened in May, 1875, having been 18 months in construction, at a cost of £12,000. It consists of one span of 162 ft., five of 40 ft., and three of 16½ ft., having massive masonry piers 52 ft. high. The roadway of the structure is 74 ft. above ordinary low water mark, but this elevation is necessary, the Manawatu being liable to sudden floods, which rise to an extraordinary height in a short space of time. Beautiful scenery abounds in the neighborhood.—*Illustrated Adelaide News.*

[NATIONAL TEACHERS' MONTHLY.]

RELATIONS OF LABOR TO EDUCATION.

By JAMES JOHONNOT.

PESTALOZZI'S first ideas of school reform included manual labor as a part of school discipline; and although he was never able to reduce his ideas to successful practice, he never gave it up in theory. In his first experiments at Newhof, with juvenile criminals, he failed in consequence of the character of the pupils he had in charge, and of his own lack of administrative and financial ability. Afterwards at Bergdorf and Yverdon reforms of a more immediate and pressing character were forced upon him, which completely absorbed his time and attention.

His friend De Fallenburg, however, undertook the neglected work and established an agricultural school, the first in manual training in his system of juvenile instruction. In the kindergarten, provision is made for intellectual culture, beginning with observation, and bringing the higher powers into use, in the order of their natural growth; for moral culture by practising the amenities necessary for the order and kindly social relations of the school-room; for æsthetic culture in the observation and production of beautiful forms; and for physical culture by rhythmic calisthenic exercises, and by the manipulation of materials, which results in manual skill. In the kindergarten practice, it has been found that the manipulations which produce physical deftness and activity are of great assistance to both moral and intellectual improvement, and that each division of the whole school work goes on much more rapidly than though exclusive attention was given to either one.

In only two classes of school in this country, besides the kindergarten, does the idea of *doing* seem to obtain;—the technical schools where the pupils are fitted for certain branches of advanced industry, and some girls' boarding schools, where a portion of the household labor is performed by the students. In neither the common schools, academies, normal schools, colleges, nor universities, does labor as a means of instruction and discipline receive attention. As far as our whole public school system is concerned, we would scarcely get the idea that manual labor is a legitimate human activity, or that it is anything more than a necessary evil to be endured, or an alternative evil to be avoided by the active exercise of the wits.

We will examine labor, first in regard to its claims as an independent activity, and second as to its educational value.

In all times past and probably in all time to come, a vast majority of human beings will get their living by some form wires which Morse proposed and Cornell erected are flashed the messages of human triumph or disaster, exciting universal sympathies and preparing the way for universal brotherhood.

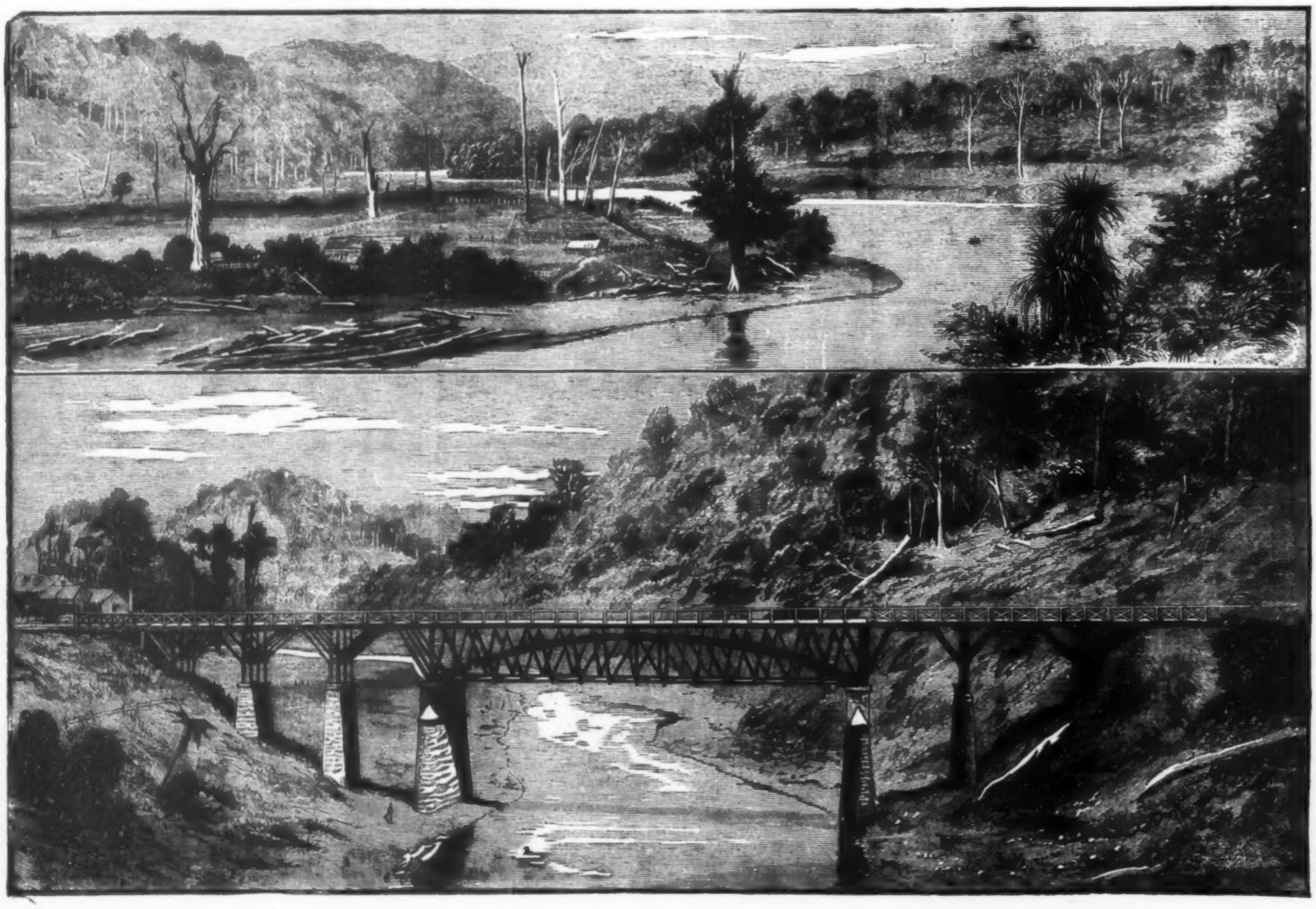
In the present, the manual labor that whitens the prairies with the harvest, that makes and controls the vast machinery of our workshops, and that lays the whole world under contribution for human comforts, engrosses nine-tenths of human endeavor, and furnishes the conditions at once of existence, of thought, and progress.

Not only do our school courses ignore the industries, but the charge is made that they directly discriminate against labor by determining all activities into exclusively intellectual channels; that the graduates of the schools avoid the shops and graduate to the counter or office; that in school, a sentiment is imbibed that disdains labor with the hands, and that looks upon the laborer with the lofty condescension of a superior being. Under this system it is declared that separation of the laborer and the scholar is becoming wider every day; that no special inducements are offered the workman to obtain an education, and that he increasingly avoids the schools. By this course, it is claimed that the industrial arts, more and more relegated to ignorant men, must deteriorate, and the spirit of caste become rife. How can education answer these charges except by pleading guilty, asking mercy and promising reform?

Let us next consider the value of labor as one of the factors of education.

In every department of education intellectual processes are quickened and invigorated by the manipulation of materials; by the practical doing; by the application of theory to practice; by the conversion of thoughts into acts

This muscular exercise necessary to manipulation trains



MANAWATU GORGE AND BRIDGE CONNECTING THE PROVINCES OF NAPIER AND WELLINGTON, NEW ZEALAND.

the world. Here he endeavored to put in practice a theory, which, though founded upon Pestalozzi's idea, was greatly in advance of it, namely, that education may be obtained through the vocation which yields daily bread at present, and is to be followed hereafter. In many respects his experiments were so successful, that he is justly regarded as the father of technical industrial education; but in the matter of earning support while engaged in study, his success was so little that it amounted to practical failure.

Attempts to make education self-supporting, through the labors of the students, have since frequently been made, but have failed in every instance. The law in the conservation of vital forces shows that, in school, physical labor pushed to the self-supporting point so exhausts as to render any considerable amount of intellectual labor impossible, while intellectual labor pushed to the point of most successful acquisition so exhausts as to render considerable physical labor impossible. This law is now so firmly established that we are warranted in predicting that, in the future, efforts to sustain schools by the labor of the students must always fail.

With the abandonment of the idea of a self-supporting education through manual labor, there seems to have been also a practical surrender of the idea that manual labor should constitute a part of school discipline. A little examination will show that these two ideas are not identical, and indeed have little relation to each other. We teach a pupil arithmetic without expecting him to earn his living, while learning, by calculating interest for a bank; we teach him literature, without considering the market value of the crude essays and poetry he writes during the process. So manual skill may be obtained in school, when the rude products have no actual money value.

Frœbel, a disciple of Pestalozzi, incorporated the idea of of manual labor. In the very dawn of civilization manual labor tamed the wild animals, cultivated the fields, and performed the work in which present thought and comforts had their origin. A step in physical progress caused by manual labor has preceded each step in intellectual progress and made it possible. The thoughts of mankind had scarcely more than an ephemeral existence until they were reduced to writing by manual dexterity; and the spread of thought to the remotest corners of the earth was rendered possible only by the invention of Guttenburg and its application by millions of skilled hands. The past has come down to us through its monuments and its literature, the results of its labor and thought, both beneficent to us, and both indispensable to our welfare, so that it becomes impossible to rank one as more important than the other. Literature is preserved by the paper maker, the type founder, the printer, the binder, and the architect, the labor and the thought being so intermarried as to render divorce impossible.

In every department of human endeavor, we find the same intimate association of thought and labor. It is shown equally in the most common affairs, and in those new departures which are the milestones of human progress. Civilization was isolated and provincial until the construction of the compass gave men the means of intercommunication. Astronomy came to a standstill until the construction of the telescope opened a new world to thought. The minute operations of nature were profound secrets until the construction of the microscope enabled investigators to deal with them.

Watt, by his force of thought and skill in manipulation, gave us the mighty power of steam, and Stephenson and Fulton applied the power to the transportation of human beings and the products of human industry over the land and the seas, making a neighborhood of the nations. Upon the the perceptive powers. Muscular and nervous fibres are intermingled throughout the system. Nervous sensibility leads to muscular exercise and development; and muscular activity reacts, promoting nervous vigor. From the muscles as well as from the nerves of special sense, sensations are conveyed to the brain which are transmuted into emotion or intelligence; and ideas in turn are worded into muscular fibre where they are manifested in semi-automatic action, and are transmitted to the next generation in the form of tendencies or instincts.

The eye of the watchmaker sees minute objects that escape the eye of ordinary observers. The dealer in wool makes his assortments by the sense of touch rendered acute by long practice. Dealers in dry goods detect qualities in the same manner. In the apparently monotonous click of the telegraphic instrument the operator not only gathers intelligence, but is also able to detect individual characteristics in the operator at the other end of the line. The trained naturalist observes facts and discovers relations in plants and animals which are not perceived by ordinary men. In each of these cases the special power was the result of combined muscular and nervous action.

In ordinary school affairs the same fact may be observed. The boy almost intuitively grasps the laws of mechanical forces, because, in his play and in his work, he has seen their practical operations. The girl frequently is not interested in this study, because her experience has not led her to handle mechanical tools, or become acquainted with their properties. The girl on the contrary usually delights in the study of color, its analysis and combinations, a subject in which the average boy takes but little interest; the difference largely depending upon the fact that one has had experience in the manipulation of colored materials, and the other has not. The pupil most noticed for his power of ab-

stract study is not unfrequently the poorest penman in the class; while the honors in this department are carried off by some one who has had the advantage of hand training at home.

CAST STEEL GUNS.

*Experiments with the New Artillery made from Steel without Blows.**

By M. GAUTIER, C.E.

AT the last meeting of the Institute, I exhibited several 8-in. and 10-in. shells, made out of steel without blows, which had been simply cast, tempered, and reheated. These had penetrated armor plate of a thickness equivalent to their diameter at an angle of 30°. These remarkable results were obtained not only in France but also by the Italian and Russian navies. In such oblique firing the work of perforation becomes complex. The first action on contact is one of compression; this is followed by a certain amount of flexion, which tends to bring the projectile to a position perpendicular to the plate at the point of least thickness; at last, after penetration of the conical heat, comes the friction of the cylindrical portion against the rough edges of the hole, which tends to elongate the shell longitudinally. Such a metal resisting both tension and compression against instantaneous deformation is remarkable. We then confidently expressed a hope that the time was nigh when artillery would be made from steel without blows as powerful as from the best forged steel, and not much more difficult to manufacture than the old cast-iron and gun-metal cannon. This result has now been obtained, the first experiment having been tried on the 17th of August last, in one of the French Government arsenals.

On whatever basis we study the resistance of elastic tubes, it is easy to see that the portion of a cannon made in one piece which suffers the most must be that portion wherein deflagration of the powder occurs. This action decreases rapidly, so that in certain cases the doubling of the thickness of metal does not increase the resistance by more than 10 to 19 per cent. In order to overcome this inequality of molecular work in heavy ordnance, it is well known that a succession of concentrical envelopes has been employed, applied in close contact to one another and compressing the central portion in a permanent manner. When the powder is exploded this compression, which decreases from inside out, must be overcome, after which the metal acts only by traction in a regular manner, from the center to the periphery. The French heavy artillery is based on this principle, and is formed of three elements: 1, the central tube which has most duty to support and is made from hammered cast steel; 2, the body, which is cast iron, although a better material might be found; 3, the frettes in puddled steel, which produce the desired compression.

The most severe test which the steel without blows could be made to resist was by employing it in the shape of a simple tube.

Such a one was cast at Terre-Noire of a diameter of 8 in., and this was bored by a hole 5 in. in diameter, so as to leave only 1¼ in. of metal on the outside. Nothing else was done besides a tempering and reheating, after which it was grooved and a screw head adopted to carry the breach.

Before proceeding to the conclusive experiments, several pieces of the metal cut perpendicularly to the axis of the tube were tested with the following results:

—		Limit of Elasticity. Tons per Square Inch.	Charge of Rupture. Tons per Square Inch.	Lengthening. Per Cent.
At the back	No. 1.	20.0	42.5	11.1
"	No. 2.	22.2	39.6	8.7
In front	No. 1.	22.5	38.1	15.1
"	No. 2.	22.7	38.5	15.0

Several pieces 1¼ in. square and 6 in. long were next submitted to the shock of a ball weighing 40 lb., and allowed to fall from increasing heights. The supports were 5 in. apart, and rested on an anvil weighing 1,800 lb. These pieces resisted well, and one of them did not break when the ball fell from 8 ft. in height, which gave it a bend in center of about 1 in.

The French Government having imposed for the trials of all steel tubes destined for the Navy:

	Tons per Square Inch
Limit of elasticity	21
Charge of rupture	38

It will be seen from the above that the tube in steel without blows answered more than the requirements. For the experiments with powder the tube was mounted on a portable carriage, after having been placed in a suitable collar.

Twenty shots were first fired with the ordinary war charge of 9 lb. of powder and the 40 lb. shell; after this 10 shots with a shell weighing 47 lb., and from this time forward the charge of powder was successfully increased by ½ lb. every ten shots, the shell remaining identical until the 100th shot was fired. At this point the chamber was quite full, and the charge had to be rammed in order to get it into place, and much difficulty was found in closing the gun. The experiment was stopped at this point as the official regulation test had been accomplished. After each 10 shots the tube was washed out with care, and measured by means of precise instruments in every portion of its course. No fissure of any kind was discovered, and the deformation of the chamber was found to be less than half of the average in forged steel tubes. Other tubes will be submitted to trial very shortly, two of which will have an internal diameter of 4 in. only. One has been cast of 13½ in. outside diameter for a gun, the body of which in cast steel is to weigh 19 tons. As the central tube is the more delicate portion of the cannon, I have little doubt of success in manufacturing the body also in steel without blows, and that we will soon turn out, with very limited means of manipulation, artillery castings weighing 20 tons each. Experience will soon teach us if we are right in this matter.

The remarkable results of those first experiments show, if nothing else, that we have had to deal with a metal possessing very interesting and valuable properties, well worthy the attention of engineers.

* Paper read before the Iron and Steel Institute at Newcastle.

ELASTICITY OF METALS AT DIFFERENT TEMPERATURES.

By G. PISATI.

THIS is a continuation of the author's researches on the elasticity of metals as measured by torsion (this Journal, 1877, i, 38). In this portion of the memoir the author gives in detail the results he has obtained with wires of iron and steel both annealed, of copper and brass both hard and annealed, of hard gold and aluminum, and with platinum both hard and annealed. From the numbers obtained it would appear that the hard metals have generally a higher modulus of torsion than the corresponding metals when annealed, but that for each metal the difference between the moduli decreases with elevation of temperature, and that in such a manner that the curves of the moduli would ultimately intersect; this actually happens in the case of copper at 250°. The total number of oscillations is usually greater for the annealed metals, although the contrary is the case with brass from the ordinary temperature to 165°, and for platinum above 220°, but in order to compare rigorously the influence of annealing on the various metals as affecting the total number of oscillations occurring at various temperatures, it would be necessary to make experiments with perfectly similar wires of hardened and annealed metals under precisely identical conditions.

It is noteworthy that after the second series of experiments made with the annealed brass wire in the manner employed by the author and previously described, the total number of oscillations, instead of increasing or remaining constant, diminished rapidly until they were nearly the same as those of the first series, a corresponding change occurring in the mean duration of the oscillation. It would seem also that at no temperature does aluminum rigorously fulfil the law of Weber and Gauss, the experimental numbers differing considerably from the calculated ones.—*Gazetta Chimica Italiana.*

GLASS IMPERVIOUS TO GASES.

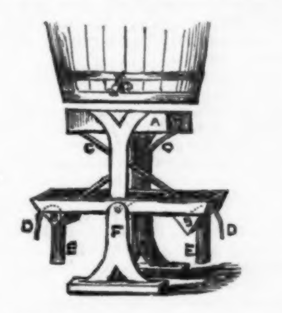
By G. QUINCKE.

THE author's experiments prove that glass 1·5 mm. in thickness is capable of retaining for 17 years, without sensible loss, hydrogen gas having a tension of 100—126 atmospheres, or from 1,500 to 1,900 lbs. per square inch. The same result was obtained with carbonic acid gas under somewhat lower pressures.—*Pogg. Ann.*

A SELF-ACTING PRINT WASHING MACHINE.

By W. A. NICHOLAS.

A IS a dish to contain the prints, with openings each end to carry off the water. B B, vessels to receive the water after running through the prints. C C, shoots to conduct the water from the dish. D D, self-acting syphons to draw the water off from bottom vessels. E E, two short legs to keep the machine from rocking over too far. F, stand. To set it in motion proceed as follows: Place the prints in the top dish; turn on the water; as soon as the water rises to one of the openings, one of the shoots (C) will convey it to the opposite side under vessel; as soon as that gets sufficiently weighted with water, it will cause the machine to rock over to the other side, thereby giving the prints a good moving about; the water will then run out of the opening at the other end of the dish, and be conveyed by the shoot to the opposite end under vessel; while that is going on the syphon D draws off the contents of the now full vessel, then



by lightening it ready to rise again as soon as the other fills; as each vessel fills and empties itself, so it rocks backward and forward. Mine has a fall of between three and four inches, which knocks the prints about with sufficient force to turn some of them over—it does not break them.

I would not be without mine on any account, as all I have to do is to turn on the water, and I know that about every two pints of water that runs through the prints gives them a good shake-up. Mine is very simply made. The top dish, fourteen by ten by four inches deep, is made of japanned tin, as also the under vessels, and the frame of light wood working on a loose axle. As will be seen by the sketch, the syphons are let through the sides of the vessels, so that when it cants over the syphons become covered by the water, which, of course, causes them to act. Distance from axle to top of dish, eighteen inches, same from axle to outside edge of under vessels.—*Photographic News.*

CLEANING OF PLATES AND LENSES.

All persons who work in photography know, or should know, that to clean lenses, and to preserve the polish of their surfaces, they should not be wiped with a cloth, but after having removed the dust by means of a brush, they should be covered with a thin coating of grease, then wiped with a piece of very soft chamois. An amateur asserts that for this purpose there is nothing better than chicken grease. Without contesting the merit of this fatty body, we simply use tallow, which we recommend not only for lenses, but also for plates which are to be collodionized. The dealers in glass plates for clichés coat them with grease, and simply wipe them before delivering them to photographers, and it is known that these plates generally give very pure clichés without any other cleaning. Many methods have been suggested for removing the varnish from old plates. A mixture of benzine and alcohol in equal parts, agitated and poured on the plates, generally acts very quickly and very well. The last traces of reduced silver which may yet adhere are then removed by iodized alcohol (alcohol 100, iodine 0·50). When the surface is properly cleaned it is rubbed over with the finger or a tuft of cotton lightly impregnated with tallow, and wiped dry. Plates thus prepared may be kept indefinitely, and are protected from dampness, the enemy which too often interposes itself between the collodion and its support. It is well to rub the plates, whatever may have been the previous mode of cleaning, with a little talc, which increases the adherence of the sensitized coating, and does away with the gelatine or albumen, the use of which would otherwise be indispensable for the preparation of dry plates. —*Bulletin Belge.*

RAPID COLLODION.

M. GOUGENHEIM has sent to the Photographic Society of France a number of bottles of a rapid collodion, of which the following are the formulæ:

COLLODION.

Ether	6700	parts.
Alcohol	5955	"
Cotton	1	part.
Double iodide potassium and cadmium	46	parts.
Iodide of ammonium	30	"
Iodide of cadmium	20	"
Bromide of cadmium	22	"

DEVELOPING SOLUTION.

Filtered water	500	parts.
Sulphate of iron	50	"
Sulphate of copper	10	"
Acetic acid	17	"
Alcohol	10	"

SILVER BATH.

Neutralized at seven per cent.

INTENSIFIER.

Distilled water	250	parts.
Pyrogallic acid	3	"
Acetic acid	10	"
Alcohol (36°)	10	"

SOLUTION OF NITRATE OF SILVER FOR INTENSIFICATION.

Distilled water	50	parts.
Nitrate of silver	1½	"

—*Bulletin Belge.*

SENSITIVENESS OF BICHROMATE SALTS.

IT is not altogether a matter of indifference which of the double compounds of chromic acid with oxygen and a base is used as a sensitizing medium, since their susceptibility to decompositionby light differs greatly, and so consequently does their sensitiveness to light. The ease with which they are crystallized and the difficulty of dissolving them are greatly detrimental to their sensitiveness to light, which depends upon:

1. The quantity of the ingredients required in the preparation of the salt.

2. The equivalent of the metallic oxide combined with the chromic acid.

3. The stability of the compound formed by the acid with a metallic oxide.

4. The use with which the monochromate salt of a metallic oxide can be decomposed. This property is, however, peculiar to the ammoniac salts.

The greatness of the quantity of a salt which can enter into a preparation depends upon its solubility in water, as when very soluble a salt is not so quickly formed by drying in prepared crystals. In this quality the bichromate salt of potassium is considerably surpassed by the bichromate salts of ammonium, lithium, sodium and calcium.

The two last named double salts are so deliquescent that they can be added to organic matter in almost unlimited and increasing quantities. They also furnish preparations very sensitive to light; but their deliquescence is a great hindrance to their manufacture and to their being largely used in commerce. The lithium salt is also excluded from practical use on account of its high price; it is the same with the double salts of the oxides of the earthy metals, as their solutions act on organic matter almost like free chromic acid, and are decomposed in its presence without exposure to light, the second equivalent of the chromic acid being too feebly combined with the base.

There remains, therefore, only the ammonium salt, which is very soluble in water, and, like the potassium, is sold in beautiful large crystals.

The second condition required to produce great sensitiveness to light is a small equivalent of the metallic oxide. The smaller the number of equivalents of the base the greater the proportion of chromic acid present in equal quantities of the prepared salt, and, therefore, the greater its sensitiveness to light.

On computing the proportions of chromic acid present in the double salts they will be found to correspond to the following scale:

100 parts of bichromate of potassium contain 68·2 parts of chromic acid, and 31·8 of the metallic oxide.
100 parts of sodic salt contain 76·4367 parts of chromic acid, and 23·5633 of the metallic oxide.
100 parts of bichromate of lithium contain 94·356 of chromic acid, and 5·644 of the oxide of the metal.
100 parts of the calcium salt contain 78·22 parts of chromic acid, and 21·78 of the basic oxide.
100 parts of the ammoniac salt contain 79·46 parts of chromic acid, and 20·54 of the basic oxide.

According to these figures the lithium salt contains the largest, and the potassic salt the smallest, percentage of chromic acid.

The sodic, potassic and ammoniac salts vary but little from each other, and, on the grounds already stated, the ammoniac seems the most suitable of these three salts for use as a sensitizing compound.

The third requirement for the production of sensitiveness—namely, the degree of cohesion between the chromic acid and the metallic oxide—is also most favorable in the ammoniac salt.

The monochromate salts of potassium, sodium and lithium have an alkaline reaction, and the bases of their compounds seize the second equivalent of chromic acid in the double salt better than the ammonoxide, and are not so easily and quickly decomposed as the latter by the action of the light.

Lastly: ammonoxide is distinguished from other bases by the rare property of being so sensitive to light in its monochromic compound with chromic acid as in its double compound with that acid. If any chromic double salt be neutralized with caustic ammonia the latter evaporates from the compound after drying, leaving the original double salt. The sensitiveness of the preparation is thus not impaired in the slightest degree by this addition.

Bichromate of ammonium, when neutralized to the single salt with caustic ammonia, owing to the partial evaporation

of the caustic ammonia, returns again, after being dried, to the double salt, which in presence of organic matter is decomposed by light, leaving *a monochromate salt* and a chromium peroxide. The monochromic salt of ammonium, however, gives up by evaporation a further part of its caustic ammonia, and is again changed into a double salt, which is in turn decomposed by the continued action of the light, and this process is repeated as long as there is any chromic acid remaining in the compound. This process, which actually goes on when preparations furnished with chromated ammonium salts are exposed to the light, is the cause of the extreme sensibility of these salts to the action of light, which exceeds that of the potassic salts by three times. The high price of chromate of ammonia, however, prevents its use becoming so general in the various printing processes as its usefulness would make desirable.—PROF J. HUSNIK, *in Photographische Monatsblatter.*

SIMULTANEOUS EXPOSURE AND DEVELOPMENT.

By ERNEST BOIVIN.

MUCH attention is now being paid to emulsion processes, in the hope of realizing the following conditions: Sensitiveness, facility of preparation, and certainty in the results. The most simple process now in use requires at least twice as much labor as the wet process, and it is in the hope of finding something more simple than is now known, that I have undertaken experiments in this direction. I have accepted as the best base the ingenious emulsion process, as it does away with a great number of operations used in the preparation of the present negatives, opening up besides a new path—that of *simultaneous development.*

It seems a strange assertion to make, that we may simply collodionize a plate, place it in a frame and expose it, and some hours afterwards on opening the frame, find there a print which, for its final completion, requires nothing more than the operation of fixing. With the new emulsion process this is not only true, but of very easy execution.

The plate simply collodionized develops itself spontaneously after the exposure, so that we need not be concerned about sensitizing, washing, and developing; the necessary operations to be performed are reduced to a minimum; collodionizing, exposure, and fixing.

By using the valuable indications given by Messrs. Carey Lea, Liesegang, Sayce, and Bolton, and quite recently by Mr. Chardon, I have been able to obtain prints spontaneously developed, which lead me to hope to make this process practicable.

Without entering into long details (which I will give hereafter), I will briefly state my mode of operation to reach the result mentioned, and to obtain the specimen accompanying this communication.

Take 30 c.c. (8 fl. drachms of my emulsionized collodion, to which add from 5 to 10 drops of gallic or pyrogallic acid at 10 per cent. in alcohol, from 3 to 5 drops of acetic acid saturated with acetate of lead, and about 1 c.c. (17 minims) of pure glycerin.

This preparation should not be made too long beforehand as it does not keep for any length of time. These substances are well shaken with the emulsion, and the collodionizing is made upon plates previously prepared with a coating of caoutchouc varnish, to which preference should be given. As soon as the collodion is fixed it is placed in the frame and exposed for about double the time required for an ordinary wet plate. The exposure finished, the frame is removed and laid aside, with the plate in it; or the plate is taken out and placed in a box, at the bottom of which are a few sheets of damp, bibulous paper, being kept at a short distance above them by pieces of cork placed at the angles.

At the end of a certain time, which may vary from one to two hours, if the plate is examined we will be surprised to find a perfectly-developed image ready for the fixing operation; if too weak, nothing is easier than to intensify it afterwards, by the ordinary strengthening processes.

The prints thus obtained are vigorous, and do not seem to have a great tendency to fog. The results obtained by this process, which certainly deserves careful study, give me a favorable opinion of what may be obtained. With regard to the reproduction of contrast, there is remarkable power—buildings partially lighted in the shade may be reproduced without any glaring contrast in the lights and shadows. In any event, this process, of great simplicity, gives a rapidity which can rival that of the dry processes actually in use.—*Moniteur.*

OXYGEN forms eight-ninths of water, and half the ponderable matter of the globe is made up of this element, yet when brought up by the magic of chemistry it is but an invisible gas. Nitrogen, the other element of air, is obtained by removing the oxygen, and is a transparent, tasteless, colorless, incondensible gas.

THE RANGE OF THE HOMŒOPATHIC LAW IN THE PRACTICE OF MEDICINE.

By W. B. A. SCOTT, M. D.

I DO not wish to make this a controversial paper, and, of course, no one except myself stands in any degree committed by anything it contains. My object is simply to give such a sketch of homœopathy as may serve to indicate the existing relations between the homœopathic and "orthodox" schools, the extremely small divergence, either in theory or practice, between the most enlightened and advanced members of each, and the consequent anachronism of anything approaching to hostility or even exclusiveness on the part of either towards the other at the present day.

The scientific basis of homœopathy I have always regarded as to be sought in the law of reaction—a law of the operation of which there can be no question, although the extent of its direct practical applicability in any particular case or class of cases is a perfectly legitimate subject of discussion, and one which is very far indeed from being as yet determined. For example, no one denies that the ordinary effect of a cold bath on a healthy man is the almost immediate production of a genial glow of warmth, and this would be generally admitted to be an instance of the re-active power of the animal body; but no one has on that account been so foolish as to assert that our fire-places ought to be replaced by tubs of iced water, or even that the amount of the subsequent warmth experienced by the bather is in direct proportion to the number of degrees by which the water in which he bathed was colder than his own body, however great or small this number may have been. Again, in the mental and moral world, in which the law of reaction strikingly prevails, we all know how a simulated opposition is very generally the best method of inducing our neighbors to adopt any particular course; for instance, how the opposition so commonly made to the wish of a boy to go to sea results in stimulating the youngster's naval zeal to its highest pitch, until he either runs away from home or else makes his home so uncomfortable for everybody else that his parents are only too thankful to get rid of him at any price. We may remember, too, how Iago inflames the jealousy of Othello by his pretended defence of Desdemona: "Strain not my speech to grosser issues nor to larger reach than to suspicion." . . . . "Nay, this was but his dream," . . . . "pray, be content" . . . . "patience, I say," etc. But no one, I suppose, will maintain that this principle—a principle very much resembling that on which the Irishman is said to have driven his refractory pig to market by means of pulling it backwards by the tail—furnishes the entire basis of the whole theory of moral suasion, or that the rational method of "training up a child in the way he should go" consists in the uniform denunciation of virtue and laudation of vice. The law of reaction I believe to be one of the fundamental laws of life—perhaps its characteristic—whether in its physical, mental, or moral developments; but still there are countless other laws, which, whether we regard them as derivatives of this or as distinct in themselves, require to be duly taken into account in all endeavors to influence the body or mind of man for good or for evil. Moreover, the direct operation of the law of reaction itself is not always what might *à priori* have been expected—sometimes exactly the reverse—just as it is owing to the same law of gravitation that a stone falls, while a balloon rises, through the air. Clearly no one psychological law, however wide or even fundamental, can form the exclusive basis of any practical system of mental or moral training, and no one physical law, however wide or even fundamental, can form the exclusive basis of any practical system of mechanics. And even when a fundamental law itself is directly susceptible of some practical application, it will lead to false results if not modified in accordance with the exigencies of the particular case in point. Thus the theoretical properties of the lever are true only of an imaginary bar which is destitute of weight; and, in the actual construction of any existing lever, will give erroneous results, unless the necessary modifications are borne in mind.

All this applies with at least equal force to the practice of medicine, where the conditions are not only complex in the extreme, but very imperfectly understood. In drug medication, in particular, we know very little either of the drugs we administer or of the frame to which they are administered, to say nothing of the concurrent influences of extraneous circumstances, such as mental states, atmospheric conditions, in fact, the patient's "surroundings" generally. Such being the case, how can it possibly be expected that any one law, however extensive and radical, can afford precise indications in all cases of this department of medical practice? Nay, that, as in one of the instances referred to above, it shall not, sometimes at least, appear to be not merely modified but reversed?

The re-active part of the organisms seems singularly well illustrated by the influence of drugs. It is now pretty generally admitted that in many, if not in all, cases the action of a small dose of a drug is the direct opposite of the action of the same drug in large doses. Take, for example, alcohol and opium, where this double action will not be disputed. Does this not seem to indicate that in the former case (that of small doses) the re-active powers of the organism have been stimulated to counteract, and more than counteract, the direct influence of the drug; while in the latter case, the force of the larger dose is such as to overcome the re-active powers of the organism, and to produce, in their despite, the characteristic effects of the drug? Just as a glow of genial warmth results from a plunge in moderately cold water, while death from cold may be the consequence of prolonged exposure to arctic snows.

The question now arises whether, in drug administration, we ought, as a rule, to aim at producing the characteristic effects of a drug, thereby crushing (for a time) the re-active powers of nature; or whether we ought not rather, as a rule, to seek to call forth the energy of those re-active powers. If the latter of these alternatives be adopted, we shall not only practice in accordance with the homœopathic law (where any general pharmaco-dynamical law is directly applicable), but we shall also necessarily administer small, though I am far from saying infinitesimal, doses. And that the second alternative ought to be adopted seems to me clear from the following consideration: the re-active powers of nature beginning to assert themselves as the effects of a large dose of any drug are gradually passing away, the last state of the patient is worse than the first, as is well illustrated by the results of the administration of purgatives in cases of habitual constipation. Here, it is generally admitted, the constitutional tendency is aggravated by such a practice. So, too, in the habitual use of opiates for procuring sleep, and in the administration of alkalies to remove gastric acidity. We have high "orthodox" authority for the administration of many drugs on homœopathic principles: that of Professor Ringer for iodine, ipecacuanha, acids and alkalies generally, and some others; while Burness and Mavor almost go so far as to assert that all drugs ought to be given on these principles. The only question, therefore, between us is as to the extent to which the homœopathic law is applicable in practice.

Now, as I have not the most distant right to constitute myself the spokesman of the homœopathic party, I can merely give my own opinion on the subject. I think we ought to endeavor to practise in accordance with the homœopathic law when we have before us (*a*) a general pathological condition which we desire to remove *in toto* and (*b*) a drug capable of producing in the healthy body a similar morbid state. Evidently, if the law of reaction holds good at all, a small (I do not say infinitesimal) dose of this drug will here call into play precisely those re-active powers in the organism which are adapted to remove this pathological condition. There are, certainly, other cases where a drug may be successfully employed for the removal of merely a single symptom to which it is homœopathic; thus Professor Ringer has successfully treated the vomiting of pregnancy by means of ipecacuanha, but I do not thing that in such cases as these the homœopathic law will very generally be found applicable. In fact, in some such cases, I think direct "allopathic" medication to be called for. For instance, take the case of an individual of a relaxed habit of body suffering from an accidental attack of constipation. Here I should advise the administration of a purgative, because I should feel that while this would remove his present uneasiness, the reaction it would subsequently call forth would necessarily be beneficial rather than otherwise. Besides all this, supposing a man of good general health, but temporarily suffering from the *malaise* consequent on an accidental costiveness (the result, perhaps of some error in diet), were to consult me, I, at least, should feel no hesitation in ordering him a dose of salts, or the like. Many similar cases occur in which direct "allopathic" medication seems to be indicated.

But in a very large proportion of cases, neither homœopathy nor allopathy will give us any help, as, for instance, those calling for "analeptic" treatment by cod-liver oil, etc. Again, it would be difficult to apply hydropathy or electricity on the law either of opposites or similars. Furthermore, in the case of intestinal worms, or of parasitical skin diseases, our object must simply be to destroy and remove the parasite which occasions the disease, by means as little as possible injurious to the human frame. Lastly, much of our treatment must long remain empirical; that is to say, experience has shown certain drugs to be useful in the treatment of certain diseases, but the precise relation of the said drugs to the said diseases—whether homœopathic, allopathic, enantiopathic, or what—remains to be discovered.

Owing to the unfortunate tendency which still prevails in some quarters wilfully or ignorantly to confound homœopathy with Hahnemannism, it here becomes necessary to say a few words about the doctrines of Hahnemann and some of his earlier disciples, respecting blood-letting and local treatment. As to the first of these, there is now but little difference of opinion between the leaders of the "orthodox" school and the homœopathists; while none of the latter is bound to deny that bleeding may be occasionally useful in the way sanctioned by the late Professor Hughes Bennett, viz., not on the antiphlogistic principle, but as a means of affording mechanical relief where the heart, owing to its state of venous engorgement, has become incapable of contracting on its contents. With regard to the latter, the deprecation of local treatment, so far from being an innovation of Hahnemann's, is at least as old as the time of Zamolxis, but, be it ancient or modern, it must be conceded that the denunciation of the practice *in toto* resulted from an imperfect acquaintance with pathology. For this imperfection Hahnemann is in no way answerable, as the science may almost be said to have sprung up since his death, but the later homœopathists, enlightened by the discoveries of modern research, have long recognized this defect in Hahnemann's teaching, which they are no more bound to defend or adopt than their "orthodox" brethren are bound to sanction certain discarded doctrines of Hunter. In any case, it has no necessary connection with the doctrine of homœopathy, which doctrine, and not Hahnemannism, is the subject of debate. Similar remarks apply to the famous "psora" doctrine, be it in any degree true or be it wholly false; but it is only fair to Hahnemann to repeat that he has been most unjustly and inconsistently treated regarding it. At one time he has been denounced for introducing an absurd novelty; at another reviled as a mere plagiarist. The doctrine was sneered at by Sir James Simpson and others as the itch-doctrine of the homœopathists, while, on the other hand, Schönlein, of Berlin, tells us—"Among the older physicians we particularly notice Autenreith, who wrote a masterly treatise on the subject, so that it was particularly impudent in Hahnemann to pretend that he was the first to point out the consequences of the itch." The fact is, the doctrine, under various names, is of unknown antiquity. We find traces of it even in classical Hindoo medicine—something very similar is referred to by Paracelsus as tartar; and so far was Hahnemann from claiming to be the discoverer that he adduces nearly 100 of his predecessors as having been more or less convinced of its truth.

I think it clearly appears that, in recognizing the law of similars as in many cases a valuable auxiliary in drug selection, the homœopathists have merely anticipated the doctrines of the now existing orthodox school by some 60 years; and that although this priority of discovery can hardly avoid giving rise to some natural feelings of jealousy on the part of the latter, the present coincidence of opinion and practice ought to banish all exclusive or sectarian prejudices. But it must, in fairness be admitted that a detail of practice remains to be discussed, which, although it has nothing whatever to with homœopathy, still presents a point of contrast between the practice of many homœopathists and that of their "orthodox" brethren. I allude to the occasional administration by some of the former of drugs in what have been called "infinitesimal" doses.

Now, in the first place, this has nothing whatever to do with the homœopathic law, and a physician may be a perfectly consistent homœopathist who is an utter disbeliever in the efficacy of "infinitesimal" doses. The doses of drugs given in accordance with the law of similars must indeed evidently be less than those necessary to produce their physiological action, but Burness and Mavor consider this ought to be the general rule of drug administration, and in the writings of Professor Ringer we may notice how strong the feeling is on the part of the "orthodox" party in favor of the diminution of the dose. How far this diminution must proceed is matter of direct experimentation in the case of each drug, and, in fact of each patient, as the susceptibility of different individuals to the action of special drugs varies greatly. In the next place, those who believe in the occasional efficacy of "infinitesimal" doses are by no means required to base their belief on the celebrated "dynamization" theory of Hahnemann. This theory was rejected by the late Professor Henderson himself, and it must be admitted that Hahnemann was far from being uniformly felicitious in his theoretical explanations, and still more in his illustrations. Those who admit the efficacy of such doses accept this simply as a fact, inexplicable perhaps, but demonstrated, in their opinion, by results which they believe themselves to have witnessed. This distinction is of real importance. For example, anyone who should seek to account for some of the alleged phenomena of "spiritualism" on the supposition that they are to be attributed to the direct agency of denizens of the unseen world would, in all probability, have his judgment arraigned by the majority of thinking men. But it would be extremely rash on this account to impute either to folly or to imposture a candid admission that certain phenomena have been occasionally witnessed at *séances* of which it is difficult or impossible to give any explanation. To admit a fact of which we believe ourselves to have witnessed the occurrence is one thing, and the admission is, at worst, merely such an error as the wisest of us is liable to fall into; to insist on any particular explanation of such a fact is quite another thing, and may be a proof of the last degree of rashness and credulity. If men had always refused their belief to all phenomena of which they were unable to give a *rationale*, the range of human knowledge would have been considerably more limited than it is at the present day.

A priori anticipations are, no doubt, hostile to a belief in the efficacy of "infinitesimal" doses; but, in scientific matters, *à priori* reasoning ought to possess but little weight, and, where observation is possible, the former is next to worthless. Now, of those who have made personal trials of the matter, and have witnessed the results of treatment by means of "infinitesimal" doses, either in homœopathic

hospitals, dispensaries, or private practice, the large majority feel convinced that in some instances such doses have manifested a curative effect. Of course these observers may have been mistaken; *post hoc* is not always *propter hoc*, and in all probability they have sometimes—perhaps often—ascribed to the action of the globule or pilule what was in reality due to pure imagination on the part of the patient. But after all due allowance has been made for this and other sources of error, there still remains a sufficient mass of evidence to convince the majority of homœopathists that in some cases "infinitesimal" doses may exert a curative influence. And, while it ill becomes anyone to speak too dogmatically on so difficult a subject as this, it must be remembered that these homœopathists are the only persons who are entitled to express an opinion on the matter with the least pretence to authority. The *à priori* denial of their opponents who have made no trial of the question is, of course, simply the arrogant dogmatism of sheer ignorance, like that of the old philosophers, who, on equally plausible *à priori* grounds, denied the existence of the Antipodes. It is surely a very insufficient excuse for the sectarian attitude assumed by the "orthodox" towards their homœopathic brethren to allege that the latter are disposed to admit the possibility of one inexplicable phenomenon in the realm of nature more than the former are willing to acknowledge. Does this really justify the exclusion of the latter from all professional intercourse and courtesy?

Suppose, for argument's sake, that it is an error to attribute curative power to "infinitesimal" doses in any cases. It follows, in the first place, that a much greater curative power must be ascribed to imagination and the *vis medicatrix naturæ* than is generally believed, since it is beyond all dispute that numerous cures of acute and chronic maladies in their severest forms have occurred during the administration of "infinitesimal" doses and nothing else. But in the case we are supposing homœopathic pilules, etc., must be regarded solely in the light of a *placebo*; and, if the *vis medicatrix naturæ* and the force of imagination are really so potent as (on this supposition) they must be assumed to be, *placebos* may advantageously be administered even in the most serious cases. The "orthodox" themselves employ *placebos*, though of a different nature. It will surely never be deemed an adequate apology for splitting the medical profession into two hostile camps to allege that the *placebo* of the homœopathists consists of sugar of milk, while that of the "orthodox" consists of bread pills or syrup of saffron.

Lastly, if it be inquired why the homœopathists continue so highly to extol Hahnemann, while they admit him to have fallen into so many errors, I reply that his errors were, for the most part, the errors of his age, shared often with Hunter and others of his distinguished contemporaries, while his great discovery remains his own. Everything in his moral and intellectual character loudly calls for our respect; his reverential spirit, benevolence, fortitude, industry, learning, and genius. The great historian of medicine, Kurt Sprengel, who will not be suspected of homœopathic proclivities, speaks in the most encomiastic terms of one, at least, of the works of Hahnemann, while Berzelius eulogises his genius for chemistry. No one can peruse any of his principal writings without being impressed with his profound and extensive acquaintance with medical and general literature. And, although no one law can, at least in the present state of our knowledge, furnish sufficient indications for our guidance in every case of medical practice, still, even here, that of *similia similibus curantur* is most valuable; while in the study of pharmacology it is all important. By its aid alone can we ever hope to establish any comprehensible relation between pharmaco-dynamics, on the one hand, and pathology on the other, which, as Professor Gamgee most justly remarked, must furnish the sole scientific basis of medicine. And, even in the practice of medicine itself, I doubt not that, as our knowledge of pharmaco dynamics and pathology increases, we shall find the Hahnemann law susceptible of proportionately wider application; while many cases which now appear subversive of it, or, at any rate, to lie outside its bounds, will be discovered in reality to lend it their firmest support.—*Chemist and Druggist.*

HEAT IN MUSCULAR ACTION.

The fact that in the living muscle heat always appears when the muscle does work (Heidenhain having shown that of two muscles equally weighted and undergoing equal contractions, one doing external work, while the other does none, the former gives out more heat than the latter), is an exception to the general rule in mechanics, that heat disappears when work is done. It is not, however, in contradiction to the general principle of the conservation of energy, but shows that in the living muscle, when stimulated to action, molecular processes occur, which, along with the doing of work, cause a development of heat. The relation of the heat developed to the work done had not been determined with any satisfactory accuracy, probably owing to the want of sufficiently delicate apparatus, though it might naturally be expected to help to an understanding of the phenomena. The subject has been taken up by M. Nawalichin, who, favored by the experimental means at hand in M. Heidenhain's Physiological Institute, made a careful examination of the development of heat in the active muscle. The experiments were very difficult and tedious, and, by reason of the smallness of the values to be measured, required very great foresight and care in the experimental arrangements. The full account of this investigation is given in *Pflüger's Archiv.*

The first series of experiments bore on the question of the productions of heat when a particular muscle of the frog is excited, through the nerve, by stimuli of increasing strength to increasing contractions. As during the experiments, the excitability of the preparation varies, the relation to the strength of stimulus was left out of account, and only the ratio between development of heat and height of contraction examined. The height of contraction was indicted graphically by the muscle itself on a smoke-blackened plate. The development of heat was measured by the deflection of a fine thermo-multiplier, and the stimulation of the nerve was effected by accurately measurable electric actions. The observations were only made when the needle was entirely at rest, which was very difficult to secure, so sensitive was the apparatus.

The tabulated numbers from experiment show: (1) that the sum of the *vis viva*, liberated in the muscle by increasing stimuli, increases only so long as the lifting-heights (*Hubhöhen*) increase. With certain amount of stimulus when produced by the sending of a constant current, the height of contraction reaches a maximum, and therewith, too, the production of heat. With a particular method of stimulation there is, under certain conditions, a fresh increase of the amount of contraction above the maximum amount, the so-called "supermaximal" contraction; where this occurred, the heat-production also rose. It may therefore be said that in general the development of heat increases with increased lifting-height, and decreases with decreased lifting-height.

The increase in the heat-production, however, does not take place proportionally to the increase in lifting-height, but in much quicker ratio. Of this unexpected result M. Nawalichin assured himself by repeated discussion of the numerical values obtained; but he did not succeed in determining more precisely the law of the increase.

This result led to the expectation that the same mechanical work of a muscle would be accompanied by unequal heating when the muscle raised a weight to the same height by several small contractions, and when it raised it by one great contraction. In a great contraction more heat would become free than in several small ones, the sum of which was equal to the great. Experiments (though some were difficult) fully confirmed this, especially after it was ascertained that the cooling during the longer period in the several smaller contractions, as against the shorter duration of the great contraction, did play a part.

It is shown, then, that as the stimulation increases, the temperature of the muscle, and accordingly the exchange of material, increase in much quicker ratio than the mechanical work, and that the stronger the stimulation the less favorable is the relation of the exchange of material to the doing of work.

These facts are in accordance, as M. Nawalichin points out, with the common experience that the climbing of a hill is much less heating and exhausting when we go zigzag than when we go straight up. In the former case a greater number of small liftings of the body result in the same doing of work as occurs in the second case through a smaller number of great liftings. The exchange of material, as the second series of experiments show, must essentially be greater in the second case than in the first; and on the amount of it depends, on the one hand, the development of heat, on the other the exhaustion.

In order to get at the inner connection of the phenomena observed, M. Nawalichin sought first to decide the question whether the accelerated increase in production of heat was due to the increase of the stimulus in itself or to the increase of the contraction produced by the increased stimulation. According to Helmholtz's observations, when a muscle is subjected to two maximum stimuli, one following close on the other, the second stimulus produces an increase of contraction only when, at commencement of the second contraction, the first has already reached a considerable height. If this be not the case, as happens if the interval of the two stimuli be less than $\frac{1}{600}$th of a second, the two stimulations produce no greater contraction than each alone. Now in what way does the production of heat occur in this latter case? Experiment showed that also, with double stimulation of the nerve, an increase of the heat-development only occurred when it had as result an increase in the height of contraction; the increase of the stimulus in itself is thus without influence on the amount of heat-production. Hence the cause of the quicker increase of the heat-production. That of the amount of contraction must be sought in conditions operative during the course of the contraction.

To determine these conditions the author made experimental inquiry into the relation of heat-development to the states of tension of the muscle during the progress of contraction. He found that the muscle developed less heat the less its tension before action; with which may be mentioned that this tension of the muscle, weighted and stretched by the weight, is smaller the more it has, through contraction, approximated to the natural length. Experiments, also, as to the relation of the heat-production to the change of state of tension during the act of contraction showed an influence of this, such that in each moment of action the quantity of heat depends on the tension. This suggested the idea that the greater heat-production with increasing stimulation is perhaps a consequence of the longer duration of the stronger contraction. The experiments proved, however, that this idea is not justified, for the muscle made small and great contractions in the same time.

As to the nature of the internal processes in the muscle, which may be the basis of the phenomena observed, M. Nawalichin offers the following remarks:—

"We know that the contracting muscle is a body of variable elasticity; with increased contraction its elastic force becomes less, its extensibility greater. When the muscle raises a given weight about four millimetres, the external work for each millimetre of the lifting-height is indeed the same; but nevertheless the doing of the same external work for every successive unit-length of the lifting-height will require a larger sum of contractile forces than for any earlier one, since the muscle, even with progressive contraction, varies as to its elastic properties in the direction of an increase of its extensibility. Upon the weight hung to the muscle act, when contraction occurs, both the contractile and the elastic forces of the muscle. . . . In the sum $(c + e)$ of the contractile (c) and the elastic forces (e), e becomes at first (during the contraction) smaller, with the natural unweighted length of the muscle equal to *nil*, and later, even negative. If the weight, then, be lifted a number of units of length, the value of c must increase with increasing contraction. . . . But an increase of the contractile force is only possible through increased transformation of elasticity into *vis viva*, that is, through exchange of material, which finds its expression in the increased formation of heat which I have observed. Thus, if I mistake not, the facts discovered by me connect themselves with other relations already known, and will find their application in a future theory of muscular forces."

In England it has been proven by a series of careful examinations that country boys of fourteen years average an inch and a quarter more in height and seven pounds more in weight than city boys of the same age.

SALT IN THE ANIMAL ECONOMY.

Salt is a universal necessity, the desire for which seems an instinct implanted in the animal creation, and there is a natural craving for it when it does not exist in sufficient quantity in the food presented. It is a large constituent of every one of the secretions, and forms about one-half the total weight of the saline matters of the blood, hence the importance of a proper supply of it with the food. This demand for salt is noted in the instinct of animals, as well as in the human longing for it. Animals will travel long distances and brave the greatest dangers to obtain it, even in the form of saline earths or the salt-licks of the west. Men will barter gold for it; indeed, it is said among the Gallas and on the coast of Sierra Leone, among the uncivilized tribes, husbands will sell their wives, brothers their sisters, and parents their children, for salt. On the Gold Coast of Africa salt is only second in value to gold. Mungo Park tells us that with some African tribes the use of salt is such a luxury that to say of a man, "He flavors his food with salt," is to imply that he is rich. In point of fact the value of salt, in a dietetical and sanitary point of view, has been recognized from the earliest time.

In barbarous times, the most horrible of punishments, entailing certain death, was the feeding of culprits on food without salt. Experiments of French scientists showed that flesh deprived of its salt, by being washed with water, lost its nutritive power, and that animals fed on it soon died of starvation. Even after a few days, with such a diet, the instinct of animals told them it was worthless as food, and they fed on it with reluctance, and the utmost torments of hunger were hardly sufficient to induce them to continue the diet. Though there was plenty of nutritious matter in the food, yet there was no medium for its solution and absorption, which properties salt alone can induce. The existence of such an appetite for salt in all individuals and animals shows that this substance serves more important functions than merely gratifying the palate. There is no question that many diseases our horses, cattle and sheep are liable to would be prevented by free access to salt, and where it has been given regularly the beneficial effects have shown themselves.

The utility of salt given in moderate quantities in feeding and fattening stock is highly spoken of by practical feeders, since it is conducive to the general health of animals, and is largely required in the formation of blood and the various animal juices. Animals, especially sheep, are very fond of it. Salt is said to prevent rot, scab, intestinal worms, braxy, and other diseases, which sheep are liable to contract from change of climate or situation. It increases their appetite, promotes the power of digestion, and modifies their natural timidity, and may be given to them in moderate quantities and with great advantage two or three times a week. It is also said to improve both the quantity and quality of the wool. Sheep fed on roots or succulent food are benefited by salt, which has the effect of preventing swelling or flatulence.

Experiments on animals have shown that, although salt mixed with the fodder does not much affect the quantity of flesh, fat or milk obtained from them, yet it seriously affects their appearance and general condition; since animals deprived of salt, in addition to that naturally contained in their food, become dull and heavy in their temperament, with rough and staring coats, and dim eyes; while on the other hand salt-consuming animals soon present a skin as smooth as velvet, showing a greater relish for food and giving a rapid increase of weight, consequent upon the larger consumption of food induced. Eminent authorities assert that animals which do not find it in their food or drink become less prolific, and the breed rapidly diminishes in number. During the period of suckling, also, salt given to the mother renders the milk more abundant and nutritious and with greater flavor. The flesh of animals fed with it is better flavored and more easily digested than that of animals which do not partake of it.

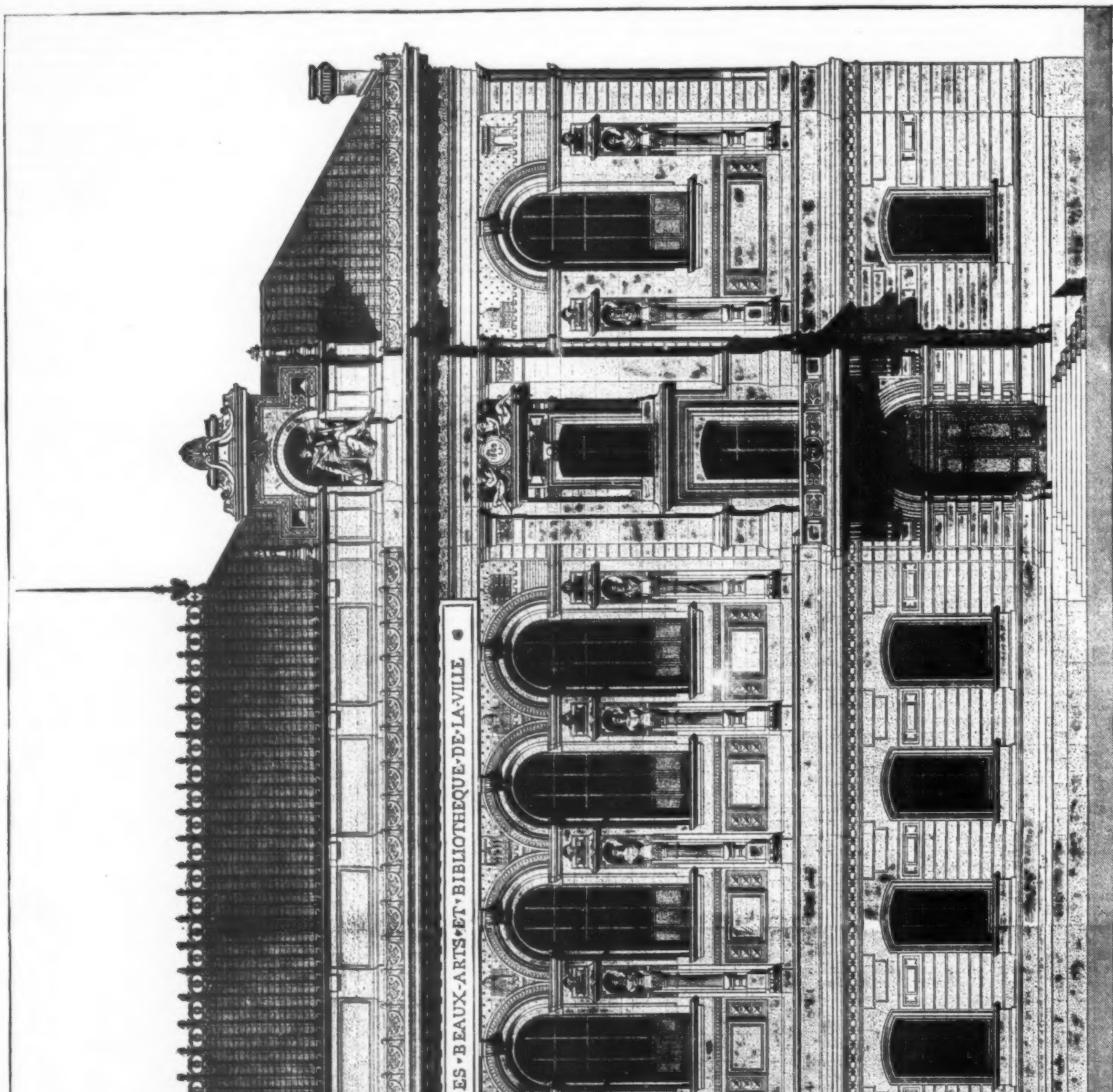
Nearly all kinds of cattle food contain more or less salt, but since the proportion varies considerably, the utility of salt will be the greatest in such food as is naturally deficient in this compound; thus one hundredweight of dry hay contains six ounces of salt, the same quantity of dry clover five ounces, while one hundredweight of beans only contains one ounce of salt, same weight of peas one-half ounce, turnips and potatoes one-tenth of an ounce, and of wheat, barley, rye, both in grain and straw, but a mere trace. It is evident that the animal requirement of salt is largely dependent upon the food given. In France and Germany the use of salt is very general among the farmers, notwithstanding its extreme price caused by high duties and government monopolies. Hardly a well managed estate exists where a small quantity of salt is not added to the food of cattle or sheep, or where they are not allowed to lick lumps of rock salt as their instincts demand.

Government investigations in France determined a recommendation for giving salt to animals with their food in the following average quantities daily: To a working ox or milch cow, two ounces; a fattening stall-fed ox, three to four ounces; a fattening pig, one to two ounces; sheep one-half to one ounce; horses, donkeys, mules, each one ounce per day. These quantities are somewhat less than is usually given, though of course the amounts vary with different conditions and foods. Cattle, horses, sheep and pigs are able to digest and thrive on food that would otherwise be rejected or prove detrimental, such as mouldy hay or damaged grain, if mixed with salt, and we can see no better proof of this than when their instinct tells them to prefer the coarse salted grass to the sweet herbage without salt. The expense of either rock salt or white salt, such as is most desirable for the feeding the animals of the farm, is a mere trifle compared with its positive and beneficial influence in keeping the stock in healthy, vigorous condition. Let every farmer make it a point to see that his cattle, horses, sheep, and swine are judiciously supplied with this all-important and inexpensive compound.—*Boston Cultivator.*

AN ANECDOTE OF SIR ISAAC NEWTON.

The house which Newton occupied, on the south side of Leicester Square, in London, is still standing, and his observatory is shown to visitors. When he took up his residence there, his next door neighbor was a widow lady, who was much puzzled by the little she had observed of the philosopher. One of the Fellows of the Royal Society of London called upon her one day, when, among other domestic news, she mentioned that some one had come to reside in the adjoining house who, she felt certain, was a poor, crazy gentleman, "because," she continued, "he diverts himself in the oddest way imaginable. Every morning, when the sun shines so brightly that we are obliged to draw the window blinds, he takes his seat in front of a tub of soapsuds, and occupies himself for hours blowing soap-bubbles through a common clay pipe, and intently watches them till they burst. He is doubtless now at his favorite amusement," she added; "do come and look at him."

The gentleman smiled, and then went upstairs, when, after looking through the window into the adjoining yard, he turned around and said: "My dear madam, the person whom you suppose to be a poor lunatic is no other than the great Sir Isaac Newton, studying the refraction of light upon thin plates, a phenomenon which is beautifully exhibited upon the surface of a common soap-bubble."



SCHOOL OF FINE-ARTS AT MARSEILLES, FRANCE.

M. ESPERANDIEU, ARCHT.

THE PHENOMENA OF HUMAN LIFE.

By JOHN TYNDALL.

THE following address was delivered by Professor Tyndall on Monday evening, October 1, 1877, at Birmingham, as President of the Midland Institute:

A magnet attracts iron, but when we analyze the effect we learn that the metal is not only attracted, but repelled, the final approach to the magnet being due to the difference of two unequal and opposing forces. Social progress is for the most part typified by this duplex or polar action. As a general rule, every advance is balanced by a partial retreat, every amelioration is associated more or less with deterioration. No great mechanical improvement, for example, is introduced for the benefit of society at large that does not bear hardly upon individuals. Science, like other things, is subject to the operation of this polar law, what is good for it under one aspect being bad for it under another.

Science demands above all things personal concentration.

Its home is the study of the mathematician, the quiet laboratory of the experimenter, and the cabinet of the meditative observer of nature. Different atmospheres are required by the man of science, as such, and the man of action.

The atmosphere, for example, which vivifies and stimulates your excellent representative, Mr. Chamberlain, would be death to me. There are organisms which flourish in oxygen—he is one of them. There are also organisms which demand for their duller lives a less vitalizing air—I am one of these. Thus the facilities of social and international intercourse, the railway, the telegraph, and the post office, which are such undoubted boons to the man of action, react to some extent injuriously on the man of science. Their tendency is to break up that concentrativeness which, as I have said, is an absolute necessity to the scientific investigator.

The men who have most profoundly influenced the world from the scientific side have habitually sought isolation. Faraday, at a certain period of his career, formally renounced dining out. Darwin lives apart from the bustle of the world in his quiet home in Kent. Mayer and Joule dealt in unobtrusive retirement with the weightiest scientific questions. None of these men, to my knowledge, ever became Presidents of the Midland Institute or of the British Association. They could not fail to know that both positions are posts of honor, but they would also know that such positions cannot be filled without grave disturbance of that sequestered peace which, to them, is a first condition of intellectual life. There is, however, one motive in the world which no man, be he a scientific student or otherwise, can afford to treat with indifference, and that is the cultivation of right relations with his fellow-men—the performance of his duty, not as an isolated individual, but as a member of society. Such duty often requires the sacrifice of private ease to the public wishes, if not to the public good. From this point of view the invitation conveyed to me more than once by your excellent senior Vice-President was not to be declined. It was an invitation written with the earnestness said to be characteristic of a Radical, and certainly with the courtesy characteristic of a gentleman. It quickened within me the desire to meet in a cordial and brotherly spirit the wish of an institution of which not only Birmingham, but England, may well be proud, and of whose friendliness to myself I had agreeable evidence in the letters of Mr. Thackray Bunce.

To look at his picture, as a whole, a painter requires distance, and to judge of the total scientific achievement of any age the standpoint of a succeeding age is desirable. We may, however, transport ourselves in idea into the future, and thus obtain a grasp, more or less complete, of the science of our time. We sometimes hear it decried and contrasted to its disadvantage with the science of other times. I do not think that this will be the verdict of posterity. I think, on the contrary, that posterity will acknowledge that in the history of science no higher samples of intellectual conquest are recorded than those which this age has made its own.

One of the most salient of these I propose, with your permission, to make the subject of our consideration during the coming hour.

It is now generally admitted that the man of to-day is the child and product of incalculable antecedent time. His physical and intellectual textures have been woven for him during his passage through phases of history and forms of existence which lead the mind back to an abysmal past. One of the qualities which he has derived from that past is the yearning to let in the light of principles on the otherwise bewildering flux of phenomena. He has been described by the German Lichtenberg as "das rastlose Ursachenthier"—the restless, cause-seeking animal—in whom facts excite a kind of hunger to know the sources from which they spring.

Never, I venture to say, in the history of the world, has this longing been more liberally responded to, both among men of science and the general public, during the last 30 or 40 years. I say "the general public," because it is a feature of our time that the man of science no longer limits his labors to the society of his colleagues and his peers, but shares, as far as it is possible to share, with the world at large the fruits of inquiry.

The celebrated Robert Boyle regarded the universe as a machine; Mr. Carlyle prefers regarding it as a tree. He loves the image of the umbrageous Igdrasil better than that of the Strasburg clock. A machine may be defined as an organism with life and direction outside; a tree may be defined as an organism with life and direction within. In the light of these definitions, I close with the conception of Carlyle. The order and energy of the universe I hold to be inherent, and not imposed from without—the expression of fixed law and not of arbitrary will, exercised by what Carlyle would call an almighty clockmaker. But the two conceptions are not so much opposed to each other after all. In one essential particular they, at all events, agree. They equally imply the interdependence and harmonious interaction of parts, and the subordination of the individual powers of the universal organism to the working of the whole. Never were the harmony and interdependence just referred to so clearly recognized as now. Our insight regarding them is not that vague and general insight to which our fathers had attained, and which, in early times, was more frequently affirmed by the synthetic poet than by the scientific man.

The interdependence of our day has become quantitative—expressible by numbers—leading, it must be added, directly into that inexorable reign of law which so many gentle people regard with dread. In the domain now under review men of science had first to work their way from darkness into twilight, and from twilight into day.

There is no solution of continuity in science. It is not given to man, however endowed, to rise spontaneously into intellectual splendor without the parentage of antecedent thought. Great discoveries grow. Here, as in other cases, we have first the seed, then the ear, then the full corn in the ear, the last member of the series implying the first.

Thus, as regards the discovery of gravitation with which the name of Newton is identified, notions more or less clear concerning it had entered many minds before Newton's transcendent mathematical genius raised it to the level of demonstration. The whole of his deductions, moreover, rested upon the inductions of Kepler. Newton shot beyond his predecessors, but his thoughts were rooted in their thoughts, and a just distribution of merit would assign to them a fair portion of the honor of discovery. Scientific theories sometimes float like rumors in the air before they receive definite expressions. The doom of a doctrine is often practically sealed, and the truth of one is often practically accepted, long prior to the theoretic demonstration of either the error or the truth. Perpetual motion, for example, was discarded before it was proved to be in opposition to natural law; and, as regards the connection and interaction of natural forces, pre-natal intimation of modern discoveries and results are strewn through scientific literature.

Confining ourselves to recent times, Dr. Ingleby has pointed out to me some singularly sagacious remarks bearing upon this question which were published by an anonymous writer in 1820. Roget's penetration was conspicuous in 1829. Mohr had grasped, in 1837, some deep-lying truth. The writings of Faraday furnish frequent illustrations of his profound belief in the unity of nature. "I have long," he writes in 1845, "held an opinion almost amounting to conviction, in common, I believe, with other lovers of natural knowledge, that the various forms under which the forces of matter are made manifest have one common origin, or, in other words, are so directly related and mutually dependent, that they are convertible, as it were, one into another, and possess equivalence of power in their action." His own researches on magneto-electricity, on electro-chemistry, and on the "magnetization of light," led him directly to this belief. At an early date Mr. Justice Grove made his mark upon this question Colding, though starting from a metaphysical basis, grasped eventually the relation between heat and mechanical work, and sought to determine it experimentally.

And here let me say that to him who has only the truth at heart, and who in his dealings with scientific history keeps his soul unwarped by envy, hatred, or malice, personal or national, every fresh accession to historical knowledge must be welcome. For every newcomer of proved merit, more especially if that merit should have been previously overlooked, he makes ready room in his recognition or his reverence. But no retrospect of scientific literature has as yet brought to light a claim which can sensibly affect the positions accorded to two great Pathfinders, whose names in relation to this subject are linked in indissoluble association. These names are Julius Robert Mayer and James Prescott Joule.

In his essay on "Circles," Mr. Emerson, if I remember rightly, pictured intellectual progress as rhythmic. At a given moment knowledge is surrounded by a barrier which marks its limit. It gradually gathers clearness and strength until, by and by, some thinker of exceptional power bursts the barrier and wins a wider circle, within which thought once more intrenches itself. But the internal force again accumulates, the new barrier is in its turn broken, and the mind finds itself surrounded by a still wider horizon. Thus, according to Emerson, knowledge spreads by intermittent victories instead of progressing at a uniform rate. When Dr. Joule first proved that a weight of one pound, falling through a height of 772 ft, generated an amount of heat competent to warm a pound of water one degree Fahrenheit, and that in lifting the weight so much heat exactly disappeared, he broke an Emersonian "circle," releasing by the act an amount of scientific energy which rapidly overran a vast domain. Helmholz, Clausius, Thomson, Rankine, Régnault, Favre, and other illustrious names are associated with the conquests since achieved and embodied in the great doctrine known as

THE CONSERVATION OF ENERGY.

This doctrine recognizes in the material universe a constant sum of power made up of items among which the most Protean fluctuations are incessantly going on. It is as if the body of nature were alive, the thrill and interchange of its energies resembling those of an organism. The parts of the "stupendous whole" shift and change, augment and diminish, appear and disappear, while the total of which they are the parts remains quantitatively immutable—immutable, because when change occurs it is always polar—*plus* accompanies *minus*, gain accompanies loss, no item varying in the slightest degree without an absolutely equal change of some other item in the opposite direction. The sun warms the tropical ocean, converting a portion of its liquid into vapor, which rises in the air and is recondensed on mountain heights, returning in rivers to the ocean from which it came. Up to the point where condensation begins an amount of heat exactly equivalent to the molecular work of vaporization and the mechanical work of lifting the vapor to the mountain tops has disappeared from the universe. What is the gain corresponding to this loss? It will seem when mentioned to be expressed in a foreign currency. The loss is a loss of heat; the gain is a gain of distance, both as regards masses and molecules. Water which was formerly at the sea-level has been lifted to a position from which it can fall; molecules which had been locked together as a liquid are now separate as vapor which can recondense. After condensation gravity comes into effectual play, pulling the showers down upon the hills, and the rivers thus created through their gorges to the sea; every raindrop which smites the mountain produces its definite amount of heat; every river in its course develops heat by the clash of its cataracts and the friction of its bed. In the act of condensation, moreover, the molecular work of vaporization is accurately reversed.

Compare, then, the primitive loss of solar warmth with the heat generated by the condensation of the vapor, and by the subsequent fall of the water from cloud to sea. They are mathematically equal to each other. No particle of vapor was formed and lifted without being paid for in the currency of solar heat: no particle returns as water to the sea without the exact quantitative restitution of that heat. There is nothing gratuitous in physical nature, no expenditure without equivalent gain, no gain without equivalent expenditure. With inexorable constancy one accompanies the other, leaving no nook or crevice between them for spontaneity to mingle with the pure and necessary play of natural force. Has this uniformity of nature ever been broken? The reply is, "Not to the knowledge of science." What has been here stated regarding heat and gravity applies to the whole of inorganic nature. Let us take an illustration from chemistry.

The metal zinc may be burnt in oxygen, a perfectly definite amount of heat being produced by the combustion of a given weight of the metal. But zinc may also be burnt in a liquid which contains a supply of oxygen—in water, for example. It does not in this case produce flame or fire, but it does produce heat which is capable of accurate measurement. But the heat of zinc burnt in water falls short of that produced in pure oxygen, the reason being that to obtain its oxygen from the water the zinc must first dislodge the hydrogen. It is in the performance of this molecular work that the missing heat is absorbed. Mix the liberated hydrogen with the oxygen and cause them to recombine, the heat developed is mathemetically equal to the missing heat. Thus in pulling the oxygen and hydrogen asunder an amount of heat is consumed which is accurately restored by their reunion. This may be taken as prefatory to a few remarks upon

THE VOLTAIC BATTERY.

It is not my design to dwell upon the technic features of this wonderful instrument, but simply to illustrate by means of it the further play of the principle of equivalence and conservation, and to show the varying shapes which a given amount of energy can assume while maintaining unvarying quantitative stability. When that form of power which we call an electric current passes through Grove's battery, zinc is consumed in acidulated water, and in the battery we are able so to arrange matters that when no current passes no zinc shall be consumed. Now the current, whatever it may be, possesses the power of generating heat outside the battery. We can fuse with it iridium, the most refractory of metals, or we can produce with it the dazzling electric light, and that at any terrestrial distance from the battery itself. We will now, however, content ourselves with causing the current to raise a given length of platinum wire, first to a blood-heat, then to redness, and finally to a white heat. The heat under these circumstances generated in the battery by the combustion of a fixed quantity of zinc is no longer constant, but it varies inversely as the heat generated outside. If the outside heat be *nil*, the inside heat is a *maximum*; if the external wire be raised to a blood-heat, the internal heat falls slightly short of the *maximum*. If the wire be rendered red-hot, the quantity of missing heat within the battery is greater, and if the external wire be rendered white-hot, the defect is greater still. Add together the internal and external heat produced by the combustion of a given weight of zinc, and you have an absolutely constant total. The heat generated without is so much lost within, the heat generated within is so much lost without, the polar changes already adverted to coming here conspicuously into play.

Thus, in a variety of ways, we can distribute the items of a never-varying sum, but even the subtle agency of the electric current places no creative power in our hands. Instead of generating external heat we may cause the current to effect chemical decomposition at a distance from the battery. Let it, for example, decompose water into oxygen and hydrogen. The heat generated in the battery under these circumstances by the combustion of a given weight of zinc falls short of what is produced when there is no decomposition. How far short? The question admits of a perfectly exact answer. When the oxygen and hydrogen recombine, the heat absorbed in the decomposition is accurately restored, and it is exactly equal in amount to that missing in the battery. We may, if we like, bottle up the gases, carry in this form the heat of the battery to the Polar Regions, and liberate it there. The battery, in fact, is a hearth on which fuel is consumed, but the heat of the combustion, instead of being confined in the usual manner to the hearth itself, may be first liberated at the other side of the world. In my youth I thought an

ELECTRO-MAGNETIC ENGINE,

which was shown to me, a veritable perpetual motion—a machine, that is to say, which performed work without the expenditure of power. Let us consider the action of such a machine. Suppose it to be employed to pump water from a lower to a higher level. On examining the battery which works the engine we find that the zinc consumed does not yield its full amount of heat. The quantity of heat thus missing within is the exact thermal equivalent of the mechanical work performed without. Let the water fall again to a lower level, it is warmed by the fall. Add the heat thus produced to that generated by the friction, mechanical and magnetical, of the engine, we thus obtain the precise amount of heat missing in the battery. All the effects obtained from the machine are thus strictly paid for; this "payment for results" being, I would repeat, the inexorable method of nature.

No engine, however subtly devised, can evade this law of equivalence, or perform on its own account the smallest modicum of work. The machine distributes, but it cannot create. Is the animal body, then, to be classed among machines?

IS THE ANIMAL BODY A MACHINE?

When I lift a weight, or throw a stone, or climb a mountain, or wrestle with my comrade, am I not conscious of actually creating and expending force? Let us look to the antecedents of this force. We derive the muscle and fat of our bodies from what we eat. Animal heat you know to be due to the slow combustion of this fuel. My arm is now inactive, and the ordinary slow combustion of my blood and tissue is going on. For every grain of fuel thus burnt a perfectly definite amount of heat has been produced. I now contract my biceps muscle without causing it to perform external work. The combustion is quickened and the heat is increased, this additional heat being liberated in the muscle itself. I lay hold of a 56lb. weight, and by the contraction of my biceps lift it through the vertical space of a foot. The blood and tissues consumed during this contraction have not developed in the muscle their due amount of heat. A quantity of heat is at this moment missing in my muscle which would raise the temperature of an ounce of water somewhat more than one degree Fahrenheit. I liberate the weight, it falls to the earth, and by its collision generates the precise amount of heat missing in the muscle. My muscular heat is thus transferred from its local hearth to external space. The fuel is consumed in my body, but the heat of combustion is produced outside my body. The case is substantially the same as that of the voltaic battery when it performs external work or produces external heat. All this points to the conclusion that the force we employ in muscular exertion is the force of burning fuel and not of creative will. In the light of these facts the body is seen to be as incapable of generating energy without expenditure as the solids and liquids of the voltaic battery. The body, in other words, falls into the category of machines.

We can do with the body all that we have ever done with the battery—heat platinum wires, decompose water, magnetize iron, and deflect a magnetic needle. The combustion of muscle may be made to produce all these effects, as the combustion of zinc may be caused to produce them. By turning the handle of a magneto-electric machine, a coil of wire may be caused to rotate between the poles of a magnet. As long as the two ends of the coil are unconnected we have simply to overcome the ordinary inertia and friction of the machine in turning the handle. But the moment the two ends of the coil are united by a thin platinum wire a sudden addition of labor is thrown upon the turning arm. When the necessary labor is expended its equivalent immediately appears. The platinum wire glows. You can readily maintain it at a white heat or even fuse it. This is a very remarkable result. From the muscles of the arm, with a temperature of 100 deg., we extract the temperature of molten platinum, which is many thousand degrees.

The miracle here is the reverse of that of the burning bush mentioned in Genesis. There the bush burned was not consumed, here the blood is consumed but does not burn.

The similarity of the action with that of the voltaic battery when it heats an external wire is too obvious to need pointing out. When the machine is used to decompose water, the heat of the muscle, like that of the battery, is consumed in molecular work, being fully restored when the gases recombine. As before, also, the transmuted heat of the muscles may be bottled up, carried to the polar regions and there restored to its pristine form.

The matter of the human body is the same as that of the world around us, and here we find the forces of the human body identical with those of inorganic nature. Just as little as the voltaic battery is the animal body a creator of force. It is an apparatus exquisite and effectual beyond all others in transforming and distributing the energy with which it is supplied, but it possesses no creative power. Compared with the notions previously entertained regarding the play of "vital force," this is a great result. The problem of vital dynamics has been described by a competent authority as the "grandest of all." I subscribe to this opinion, and honor correspondingly the man who first successfully grappled with the problem. He was no pope in the sense of being infallible, but he was a man of genius whose work will be held in honor as long as science endures. I have already named him in connection with our illustrious countryman, Dr. Joule. Other eminent men took up this subject subsequently and independently; but all that has been done hitherto enhances, instead of diminishing, the merits of Dr. Mayer.

Consider the vigor of his reasoning. "Beyond the power of generating internal heat, the animal organism can generate heat external to itself. A blacksmith by hammering can warm a nail, and a savage by friction can heat wood to its point of ignition. Unless, then, we abandon the physiological axiom that the animal body cannot create heat out of nothing, we are driven to the conclusion that it is the total heat, within and without, that ought to be regarded as the real calorific effect of the oxidation within the body." Mayer, however, not only states the principle, but illustrates numerically the transfer of muscular heat to external space. A bowler who imparts a velocity of 30-ft. to an 8-lb. ball, consumes in the act 1-10th of a grain of carbon. The heat of the muscle is here distributed over the track of the ball, being developed there by mechanical friction. A man weighing 150-lb. consumes in lifting his own body to a height of 8-ft. the heat of a grain of carbon. Jumping from this height the heat is restored. The consumption of 2oz. 4drs. 2[illegible] grs. of carbon would place the same man on the summit of a mountain 10,000 feet high. In descending the mountain an amount of heat equal to that produced by the combustion of the foregoing amount of carbon is restored. The muscles of a laborer whose weight is 150lb. weigh 64lb. When dried they are reduced to 15lb.

Were the oxidation corresponding to a day laborer's ordinary work exerted on the muscles alone, they would be wholly consumed in 80 days. Were the oxidation necessary to sustain the heart's action concentrated on the heart itself, it would be consumed in eight days. And if we confine our attention to the two ventricles, their action would consume the associated muscular tissue in three days and a-half. With a fullness and precision of which this is but a sample did Mayer, between 1842 and 1845, deal with the greater question of vital dynamics.

We place, then, food in our stomachs as so much combustible matter. It is first dissolved by purely chemical processes, and the nutritive fluid is poured into the blood. Here it comes into contact with atmospheric oxygen admitted by the lungs. It unites with the oxygen as wood or coal might unite with it in a furnace. The matter products of the union if I may use the term, are the same in both cases—viz., carbonic acid and water. The force products are also the same—heat within the body, or heat and work outside the body. Thus far every action of the organism belongs to the domain either of physics or of chemistry.

But you saw me contract the muscle of my arm. What enabled me to do so? Was it or was it not the direct action of my will? The answer is, the action of the will is mediate, not direct. Over and above the muscles the human organism is provided with long whitish filaments of medullary matter, which issue from the spinal column, being connected by it on the one side with the brain, and on the other side losing themselves in the muscles. Those filaments or cords are the nerves, which you know are divided into two kinds, sensor and motor, or, if you like the terms better, afferent and efferent nerves. The former carry impressions from the external world to the brain; the latter convey the behests of the brain to the muscles. Here, as elsewhere, we find ourselves aided by the sagacity of Mayer, who was the first to clearly formulate the part played by the nerves in the organism.

Mayer saw that neither nerves nor brain, nor both together, possessed the energy necessary to animal motion; but he also saw that the nerve could lift a latch and open a door by which floods of energy are let loose. "As an engineer," he says with admirable lucidity, "by the motion of his finger in opening a valve or loosening a detent can liberate an amount of mechanical energy almost infinite compared with its exciting cause, so the nerves, acting on the muscles, can unlock an amount of power out of all proportion to the work done by the nerves themselves." The nerves, according to Mayer, pull the trigger, but the gunpowder which they ignite is stored in the muscles. This is the view now universally entertained.

The quickness of thought has passed into a proverb, and the notion that any measurable time elapsed between the infliction of a wound and the feeling of the injury would have been rejected as preposterous 30 years ago. Nervous impressions, notwithstanding the results of Haller, were thought to be transmitted, if not instantaneously, at all events with the rapidity of electricity. Hence, when Helmholtz, in 1851, affirmed, as the result of experiment, nervous transmission to be a comparatively sluggish process, very few believed him. His experiments may now be made in the lecture room. Sound in air moves at the rate of 1,100 ft. a second; sound in water moves at the rate of 4,000 ft. a second; light in ether moves at the rate of 120,000 miles a second, and electricity in free wires moves probably at the same rate. But the nerves transmit their messages at the rate of only 70 ft. a second, a progress which in these quick times might well be regarded as intolerably slow.

A NERVOUS METAL.

Your townsman, Mr. Gore, has produced by electrolysis a kind of antimony which exhibits an action strikingly analogous to that of nervous propagation. A rod of this antimony is in such a molecular condition that when you scratch or heat one end of the rod the disturbance propagates itself before your eyes to the other end, the onward march of the disturbance being announced by the development of heat and fumes along the line of propagation. In some such way the molecules of the nerves are successively overthrown; and if Mr. Gore could only devise some means of winding up his exhausted antimony, as the nutritive blood winds up exhausted nerves, the comparison would be complete.

The subject may be summed up, as Du Bois-Reymond has summed it up, by reference to the case of a whale struck by a harpoon in the tail. If the animal were 70 ft. long, a second would elapse before the disturbance could reach the brain. But the impression after its arrival has to diffuse itself and throw the brain into the molecular condition necessary to consciousness. Then, and not till then, the command to the tail to defend itself is shot through the motor nerves. Another second must elapse before the order reaches the tail, so that more than two seconds transpire between the infliction of the wound and the muscular response of the part wounded. The interval required for the kindling of consciousness would probably more than suffice for the destruction of the brain by lightning or even by a rifle bullet. Before the organ can arrange itself, it may, therefore, be destroyed, and in such a case we may safely conclude that death is painless.

The experiences of common life supply us with copious instances of the liberation of vast stores of muscular power by an infinitesimal 'priming' of the muscles by the nerves. We all know the effect produced on a 'nervous' organization by a slight sound which causes affright. An aerial wave, the energy of which would reach a minute fraction of that necessary to raise the thousandth of a grain through the thousandth of an inch, can throw the whole human frame into a powerful mechanical spasm, followed by violent respiration and palpitation. The eye, of course, may be appealed to as well as the ear. Of this the lamented Lange gives the following vivid illustration:

"A merchant sits complacently in his easy chair, not knowing whether smoking, sleeping, newspaper reading, or the digestion of food occupies the largest portion of his personality. A servant enters the room with a telegram bearing the words, 'Antwerp, etc. . . . Joans & Co. have failed.' 'Tell James to harness the horses!' The servant flies. Up stairs the merchant, wide awake, makes a dozen paces through the room, descends to the counting house, dictates letters and forwards dispatches. He jumps into his carriage, the horses snort, and their driver is immediately at the Bank, on the Bourse, and among his commercial friends. Before an hour has elapsed he is again at home, where he throws himself once more into his easy chair with a deep-drawn sigh, 'Thank God, I am protected against the worst, and now for further reflection!'"

This complex mass of action, emotional, intellectual, and mechanical, is evoked by the impact upon the retina of the infinitesimal waves of light coming from a few pencil marks on a bit of paper. We have, as Lange says, terror, hope, sensation, calculation, possible ruin, and victory compressed into a moment. What caused the merchant to spring out of his chair? The contraction of his muscles. What made his muscles contract? An impulse of the nerves, which lifted the proper latch, and liberated

THE MUSCULAR POWER.

Whence this impulse? From the center of the nervous system. But how did it originate there? This is the critical question. The aim and effort of science is to explain the unknown in terms of the known. Explanation, therefore, is conditioned by knowledge. You have probably heard the story of the German peasant who, in early railway days, was taken to see the performance of a locomotive. He had never known carriages to be moved except by animal power. Every explanation outside of this conception lay beyond his experience, and could not be invoked. After long reflection, therefore, and seeing no possible escape from the conclusion, he exclaimed confidently to his companion, "Es müssen doch Pferde darin sein"—"There must be horses inside." Amusing as this locomotive theory may seem, it illustrates a deep-lying truth.

With reference to our present question, some may be disposed to press upon me such considerations as these: Your motor nerves are so many speaking-tubes, through which messages are sent from man to the world; and your sensor nerves are so many conduits through which the whispers of the world are sent back to the man. But you have not told us where the man is. Who or what is it that sends and receives those messages through the bodily organism? Do not the phenomena point to the existence of a self within a self, which acts through the body as through a skilfully constructed instrument? You picture the muscles as hearkening to the commands sent through the motor nerves, and you picture the sensor nerves as the vehicles of incoming intelligence; are you not bound to supplement this mechanism by the assumption of an entity which uses it? In other words, are you not forced by your own exposition into

THE HYPOTHESIS OF A FREE HUMAN SOUL?

That hypothesis is offered as an explanation or simplification of a series of phenomena more or less obscure. But adequate reflection shows that instead of introducing light into our minds it increases our darkness. You do not in this case explain the unknown in terms of the known, which, as stated above, is the method of science, but you explain the unknown in terms of the more unknown. The warrant of science extends only to the statement that the terror, hope, sensation, and calculation of Lange's merchant are physical phenomena produced by, or associated with, the molecular motions set up by the waves of light in a previously prepared brain. But the scientific view is not without its own difficulties. We here find ourselves face to face with a problem which is the theme, at the present moment, of profound and subtle controversy. What is the causal connection, if any, between the objective and subjective—between molecular motions and states of consciousness? My answer is, I know not, nor have I as yet met anybody who knows.

It is no explanation to say that the objective and subjective effects are two sides of one and the same phenomenon. Why should the phenomenon have two sides? This is the very core of the difficulty. There are plenty of molecular motions which do not exhibit this two-sidedness.

Does water think or feel when it runs into frost ferns upon a window-pane?

If not, why should the molecular motion of the brain be yoked to this mysterious companion—consciousness? We can present to our minds a coherent picture of the physical process—the stirring of the brain, the thrilling of the nerves, the discharging of the muscles, and all the subsequent mechanical motions of the organism. But we can present no picture of the process whereby consciousness emerges, either as a necessary link or as an accidental by-product of this series of actions. Yet it certainly does emerge—molecular motion produces consciousness. The reverse process of the production of motion by consciousness is equally unpresentable to the mind. We are here, in fact, upon

THE BOUNDARY LINE OF OUR INTELLECTUAL POWERS,

where the ordinary canons of science fail to extricate us from our difficulties. If we are true to these canons, we must deny to subjective phenomena all influence on physical process. The latter must be regarded as complete in themselves. Physical science offers no justification for the notion that molecules can be moved by states of consciousness; and it furnishes just as little countenance to the conclusion that states of consciousness can be generated by molecular motion. Frankly stated, we have here to deal with facts almost as difficult to be seized mentally as the idea of a soul. And if you are content to make your 'soul' a poetic rendering of a phenomenon which refuses the yoke of ordinary mechanical laws, I, for one, would not object to this exercise of ideality. Amid all our speculative uncertainty there is one practical point as clear as day—namely, that the brightness and the usefulness of life, as well as its darkness and disaster, depend to a great extent upon our own use or abuse of this miraculous organ.

IS THE WILL OF MAN FREE?

We now stand face to face with the final problem. It is this:

Are the brain, and the moral and intellectual processes known to be associated with the brain—and, as far as our experience goes, indissolubly associated—subject to the laws which we find paramount in physical nature? Is the will of man, in other words, free, or are it and nature equally 'bound fast in fate?' From this latter conclusion, after he had established it to the entire satisfaction of his understanding, the great German thinker Fichte recoiled. You will find the record of this struggle between head and heart in his book, entitled "Die Bestimmung des Menschen"—"The Vocation of Man." Fichte was determined at all hazards to maintain his freedom, but the price he paid for it indicates the difficulty of the task. To escape from the iron necessity seen everywhere reigning in physical nature, he turned defiantly round upon nature and law, and affirmed both of them to be the products of his own mind. He was not going to be the slave of a thing which he himself created. There is a good deal to be said in favor of this view, but few of us probably would be able to bring into play the solvent transcendentalism whereby Fichte melted his chains. Why do some of us regard this notion of necessity with terror, while others do not fear it at all? Has not Carlyle somewhere said that a belief in destiny is the bias of all earnest minds? "It is not Nature," says Fichte, "it is freedom itself by which the greatest and most terrible disorders incident to our race are produced. Man is the cruelest enemy of man." But the question of moral responsibility here emerges, and it is the possible lessening of this responsibility that so many of us dread. The notion of necessity certainly failed to frighten Bishop Butler. He thought it untrue, but he did not fear its practical consequence. He showed, on the contrary, in the "Analogy," that as far as human conduct is concerned the two theories of free will and necessity come to the same in the end.

WHAT IS MEANT BY FREE WILL?

Does it imply the power of producing events without antecedents—of starting as it were upon a creative tour of occurrences without any impulse from within or from without? Let us consider the point. If there be absolutely or relatively no reason why a tree should fall, it will not fall; and if there be absolutely or relatively no reason why a man should act, he will not act. It is true that the united voice of this assembly could not persuade me that I have not, at this moment, the power to lift my arm if I wished to do so. Within this range the conscious freedom of my will cannot be questioned. But what about the origin of the "wish?" Are we or are we not, complete masters of the circumstances which create our wishes, motives, and tendencies to action? Adequate reflection will, I think, prove that we are not. What, for example, have I to do with the generation and development of that which some will consider my total being, and others a most potent factor of my total being—the living, speaking organism which now addresses you? As stated at the beginning of this discourse, my physical and intellectual textures were woven for me, not by me. Processes in the conduct or regulation of which I had no share have made me what I am. Here, surely, if anywhere, we are as clay in the hands of the potter. It is the greatest of delusions to suppose that we come into this world as sheets of white paper on which the age can write anything it likes, making us good or bad, noble or mean, as the age pleases. The age can stunt, promote, or pervert pre-existent capacities, but it cannot create them. The worthy Robert Owen, who saw in external circumstances the great moulders of human character, was obliged to supplement his doctrine by making the man himself one of the circumstances. It is as fatal as it is cowardly to blink facts because they are not to our taste. How many disorders, ghostly and bodily, are transmitted to us by inheritance? In our courts of law, whenever it is a question whether a crime has been committed under the influence of insanity, the best guidance the judge and jury can have is derived from the parental antecedents of the accused. If among these insanity be exhibited in any marked degree, the presumption in the prisoner's favor is enormously enhanced, because the experience of life has taught both judge and jury that insanity is frequently transmitted from parent to child.

I met some years ago in a railway carriage the governor of

one of our largest prisons. He was evidently an observant and reflective man, possessed of wide experience gathered in various parts of the world, and a thorough student of the duties of his vocation. He told me that the prisoners in his charge might be divided into three distinct classes. The first class consisted of persons who ought never to have been in prison. External accident, and not internal taint, had brought them within the grasp of the law, and what had happened to them might happen to most of us. They were essentially men of sound moral stamina, though wearing the prison garb. Then came the largest class, formed of individuals possessing no strong bias moral or immoral, plastic to the touch of circumstances which would mold them into either good or evil members of society. Thirdly came a class—happily not a large one—whom no kindness could conciliate and no discipline tame. They were sent into this world labeled "incorrigible," wickedness being stamped, as it were, upon their organizations. It was an unpleasant truth, but as a truth it ought to be faced. For such criminals the prison over which he ruled was certainly not the proper place. If confined at all, their prison should be on a desert island where the deadly contagion of their example could not taint the moral air. But the sea itself he was disposed to regard as a cheap and appropriate substitute for the island. It seemed to him evident that the State would benefit if prisoners of the first class were liberated; prisoners of the second class educated; and prisoners of the third class put compendiously under water.

It is not, however, from the observation of individuals that the argument against "free will," as commonly understood, derives its principal force. It is, as already hinted, indefinitely strengthened when extended to the race. Most of you have been forced to listen to the outcries and denunciations which rung discordant through the land for some years after the publication of Mr. Darwin's

"ORIGIN OF SPECIES."

Well, the world—even the clerical world—has for the most part settled down in the belief that Mr. Darwin's book simply reflects the truth of nature; that we, who are now "foremost in the files of time," have come to the front through almost endless stages of promotion from lower to higher forms of life. If to any one of us were given the privilege of looking back through the eons across which life has crept towards its present outcome, his vision would ultimately reach a point when the progenitors of this assembly could not be called human. From that humble society, through the interaction of its members and the storing up of their best qualities, a better one emerged; from this again a better still, until at length, by the integration of infinitesimals through ages of amelioration, we came to be what we are to-day. We of this generation had no conscious share in the production of this grand and beneficent result. Any and every generation which preceded us had just a little share. The favored organism whose garnered excellence constitutes our present store owed their advantage, first, to what we in our ignorance are obliged to call "accidental variation;" and, secondly, to a law of heredity in the passing of which our suffrages were not collected. With characteristic felicity and precision Mr. Matthew Arnold lifts this question into the free air of poetry, but not out of the atmosphere of truth, when he ascribes the amelioration to "a power not ourselves which makes for righteousness."

If, then, our organisms, with all their tendencies and capacities, are given to us without our being consulted, and if, while capable of acting within certain limits in accordance with our wishes, we are not masters of the circumstances in which our motives and wishes originate; if, finally, our motives and wishes determine our actions, in what sense can these actions be said to be the result of free will? Here again, we are confronted with the question

OF MORAL RESPONSIBILITY

which it is desirable to meet in its rudest form and in the most uncompromising way. "If," says the robber, the ravisher, or the murderer, "I act because I must act, what right have you to hold me responsible for my deeds?" The reply is, "The right of society to protect itself against aggressive and injurious forces, whether they be bond or free, forces of nature or forces of man." "Then," retorts the criminal, "you punish me for what I cannot help." "Granted," says society, "but had you known that the treadmill or the gallows was certainly in store for you, you might have 'helped.' Let us reason the matter fully and frankly out. We entertain no malice or hatred against you, but simply with a view to our own safety and purification we are determined that you and such as you shall not enjoy liberty of evil action in our midst. You, who have behaved as a wild beast, we claim the right to cage or kill as we should a wild beast. The public safety is a matter of more importance than the very limited chance of your moral renovation, while the knowledge that you have been hanged by the neck may furnish to others about to do as you have done the precise motive which will hold them back. If your act be such as to invoke a minor penalty, then not only others, but yourself, may profit by the punishment which we inflict. On the homely principle that 'a burnt child dreads the fire,' it will make you think twice before venturing on a repetition of your crime. Observe, finally, the consistency of our conduct. You offend, because you cannot help offending, to the public detriment. We punish, because we cannot help punishing, for the public good." Practically, then, as Bishop Butler predicted, we act as the world acted when it supposed the evil deeds of its criminals to be the products of free will.

"What," I have heard it argued, "is the use of preaching about duty if man's predetermined position in the moral world renders him incapable of profiting by advice?" Who knows that he is incapable? The preacher's last word enters as a factor into the man's conduct; and it may be a most important factor, unlocking moral energies which might otherwise remain imprisoned and unused. If the preacher feel that words of enlightenment, courage, and admonition enter into the list of forces employed by Nature for man's amelioration since she gifted man with speech, he will suffer no paralysis to fall upon his tongue. Dung the fig-tree hopefully, and not until its barrenness has been demonstrated beyond a doubt let the sentence go forth, "Cut it down, why cumbereth it the ground?"

I remember when a youth in the town of Halifax, some 32 years ago, attending a lecture given by a young man to a small but select audience. The aspect of the lecturer was earnest and practical, and his voice soon riveted attention. He spoke of duty, defining it as a debt owed, and there was a kindling vigor in his words which must have strengthened the sense of duty in the minds of those who heard him. No speculations regarding the freedom of the will could alter the fact that the words of that young man did me good. His name was George Dawson. He also spoke, if you will allow me to allude to it, of a social subject much discussed at that time—the Chartist subject of "levelling." Suppose, he said, two men to be equal at night, and that one rises at six, while the other sleeps till nine next morning, what becomes of your levelling? And so speaking he made himself the mouthpiece of Nature, which, as we have seen, secures advance, not by the reduction of all to a common level, but by the encouragement and conversation of what is best.

It may be urged that, in dealing as above with my hypothetical criminal, I am assuming a state of things brought about by

THE INFLUENCE OF RELIGIONS

which include the dogmas of theology and the belief in free will—a state, namely, in which a moral majority control and keep in awe the immoral minority. The heart of man is deceitful above all things, and desperately wicked. Withdraw, then, our theological sanctions, including the belief in free will, and the condition of the race will be typified by the samples of individual wickedness which have been adduced. We shall all, that is, become robbers, and ravishers, and murderers. From much that has been written of late it would seem that this astounding inference finds house-room in many minds. Possibly, the people who hold such views might be able to illustrate them by individual instances.

"The fear of hell's a hangman's whip
"To keep the wretch in order."

Remove this fear and the wretch, following his natural instinct, may become disorderly; but I refuse to accept him as a sample of humanity. "Let us eat and drink, for to-morrow we die," is by no means the ethical consequence of free thought.

To many of you the name of George Jacob Holyoake is doubtless familiar, and you are probably aware that at no man in England has the term atheist been more frequently pelted. There are, moreover, really few who have more completely liberated themselves from theological notions. Among working-class politicians Mr. Holyoake is a leader. Does he exhort his followers to "eat and drink, for to-morrow we die?" Not so. In the August number of the *XIXth Century* you will find these words from his pen: "The gospel of dirt is bad enough, but the gospel of mere material comfort is much worse." He contemptuously calls the Comtist championship of the working man "the championship of the trencher." He would place "the leanest liberty which brought with it the dignity and power of self-help" higher than "any prospect of a full plate without it." Such is the doctrine taught by this "atheistic" leader; and no Christian, I apprehend, need be ashamed of it. Not in the way assumed by our dogmatic teachers has the morality of human nature been propped up. The power which has moulded us thus far has worked with stern tools upon a very rigid stuff. What it has done cannot be so easily undone; and it has endowed us with moral constitutions which take pleasure in the noble, the beautiful, and the true, just as surely as it has endowed us with sentient organisms which finds aloes bitter and sugar sweet. That power did not work with delusions, nor will it stay its hand when such are removed.

Facts rather than dogmas have been its ministers—hunger and thirst, heat and cold, pleasure and pain, sympathy, shame, pride, love, hate, terror, awe—such were the forces the interaction and adjustment of which, during the immeasurable ages of his development, wove the triplex web of man's physical, intellectual and moral nature, and such are the forces that will be effectual to the end.

Some may retort that even on my own showing "the power which makes for righteousness" has dealt in delusions; for it cannot be denied that the beliefs of religion, including the dogmas of theology and the freedom of the will, have had some effect in moulding the moral world. Granted; but I do not think that this goes to the root of the matter. Are you quite sure that those beliefs and dogmas are primary and not derived—that they are not the products, instead of being the creators, of man's moral nature? I think it is in one of the "Latter Day Pamphlets' that Carlyle corrects a reasoner, who deduced the nobility of man from a belief in heaven, by telling him that the belief in heaven is derived from the nobility of man. The bird's instinct to weave its nest is referred to by Emerson as typical of the force which built cathedrals, temples, and pyramids:

"Know'st thou what wove yon woodbird's nest
"Of leaves and feathers from her breast,
"Or how the fish outbuilt its shell,
"Painting with morn each annual cell?
"Such and so grew these holy piles
"While love and terror laid the tiles;
"Earth proudly wears the Parthenon
"As the best gem upon her zone;
"And Morning opes with haste her lids
"To gaze upon the Pyramids;
"O'er England's abbeys bends the sky
"As on its friends with kindred eye;
"For out of Thought's interior sphere
"These wonders rose to upper air,
"And Nature gladly gave them place,
"Adopted them unto her race.
"And granted them an equal date
"With Andes and with Ararat."

Surely many of the utterances which have been accepted as descriptions ought to be interpreted as aspirations; or as having their roots in aspiration, instead of objective knowledge. Does the song of the herald angels, "Glory to God in the highest, and on earth peace, goodwill toward men," express the exhaltation and the yearning of the human soul, or does it describe an optical and acoustical fact—a visible host and an audible song? If the former, the exaltation and the yearning are man's imperishable possession—a ferment long confined to individuals, but which may by and by become the leaven of the race. If the latter, then belief in the entire transaction is wrecked by non-fulfilment. Look to the East at the present moment as a comment on the promise of peace on earth and goodwill toward men That promise is a dream dissolved by the experience of eighteen centuries. But though the mechanical theory of a vocal heavenly multitude proves untenable, the immortal song and the feelings it expresses are still ours, to be incorporated, let us hope, in purer and less shadowy forms in the poetry, philosophy, and practice of the future. Thus, following

THE LEAD OF PHYSICAL SCIENCE,

we are brought from the solution of continuity into the presence of problems which as usually classified lie entirely outside the domain of physics. To these problems thoughtful and penetrative minds are now applying those methods of research which in physical science has proved their truth by their fruits.

There is on all hands a growing repugnance to invoke the supernatural in accounting for the phenomena of human life, and the thoughtful minds just referred to, finding no trace of evidence in favor of any other, are driven to seek in the interaction of social forces the genesis and development of man's moral nature. If they succeed in their search—and I think they are sure to succeed—social duty would be raised to a higher level of significance, and the deepening sense of social duty would, it is to be hoped, lessen, if not obliterate, the strife and heartburnings which now beset and disguise our social life. Towards this great end, it behoves us one and all to work, and, devoutly wishing its consummation, I have the honor, ladies and gentlemen, to bid you a friendly farewell.

CULTIVATION OF PEANUTS.

THE peanut has been cultivated to some extent in the South, but it is only since the civil war that it has become a product of national importance. A knowledge of its merits was gained by thousands of men from all sections of the Union during the invasion of those parts of the country where it was raised. This has raised it to a general popularity throughout the whole country. The result of this is a demand that has led to a largely increased production in those parts of the country where it flourishes Its cultivation has proved quite successful, and has yielded quite large profits. The great success attending the cultivation of this crop, and the large profits resulting from it, have led many to engage in the business who are ignorant of the conditions necessary to success. There is nothing, however, at all mysterious or difficult about either the preparation of the soil or the cultivation of the crop. Though a southern plant, the peanut is found to succeed, under favorable conditions, much farther north than was formerly supposed. The production of this crop for the market is principally confined to the States of Virginia and Tennessee, but I see no reason why it may not be made about as profitable in Kentucky, Arkansas and Southern Illinois, Missouri and Kansas. Indeed I know that in Southern Kansas it is raised with as much profit probably as any other crop. Further north (except in particularly favorable localities) it is doubtful whether the peanut can be cultivated with profit as a market crop. But for home use, in small quantities, with proper care, they may be raised with success. Experiments made a few years ago in North Central Indiana proved to me that every family, by an intelligent effort, might produce enough of these for abundant home consumption.

Any soil that is moderately rich and warm, and that will work up and remain friable and mellow, is adapted to this crop. In the South, where they are raised for market, the more desirable soil is a light gray clay, with only a small proportion of sand. This is preferred because of the light color of the pods grown in it. Dark or reddish-colored soils impart a tinge to the peanut pods that injure their sale somewhat, although the darker soils may produce just as heavy crops, and the nuts are intrinsically just as valuable as the lighter colored ones. Yet, when put on the market, the light-colored ones bring from 10 to 15 cents more on the bushel than the others do. If not particular about the color, a good, friable loam, or a sandy loam, or even a sandy soil, will produce good crops. Farther north, where the seasons are short, the warmest soils should be selected. Any soil, to produce peanuts, must contain a considerable portion of lime. In the absence of this ingredient, the vines may grow luxuriant and produce abundance of pods, but they will not fill. Where this is lacking in the soil it must be supplied. This may be done by spreading over the surface and plowing under, or by strewing in a furrow and then raising a bed for a row over it; or it may be applied as a top-dressing after the peas are planted. It is not particular what kind of lime is used, provided it is finely comminuted by burning before it is used. Near large cities, where oyster shells may be obtained in abundance, they are generally burned and used for this purpose; but common limestone, or marl, where it can be had, answers the purpose very well.

The importance of keeping the soil mellow will appear from the fact that the nut is formed on the end of a slender peduncle, or fruit stem, that is sent down from the branch of the plant. This penetrates the soil from one to four or five inches, and on the end of it the pod is formed. As this peduncle wishes to penetrate the soil till it reaches a solid bed before it forms a pod, it is best not to stir the ground more than 4 inches deep in the spring. The surface of the soil should be thoroughly pulverized by harrowing. It is then customary in the South to throw up beds some 3 feet wide and 3 or 4 inches high, in the center of which the seed is planted; but I find that here in Southern Kansas strictly flat culture gives very satisfactory results. Farther north it is probable that the ridge culture will give better results than the flat. The peas should be shelled, and planted two in a hill 3 feet apart one way and 2½ or 3 the other. Planting should be done as soon as the ground has become warm. There is nothing made by being in a hurry about this work. Last spring I planted some in April and some the first of June, and the latter planting was up before many of the former. In the Northern States, where the season is rather short for them to mature well, they may be forwarded by planting in a hot-bed, or in boxes in the house, in March, and having them well started, ready to transplant to the open ground as soon as it is warm enough for them to grow well. They transplant well, and in this way a month or more may be saved, which will often make all the difference between a good crop and a failure.

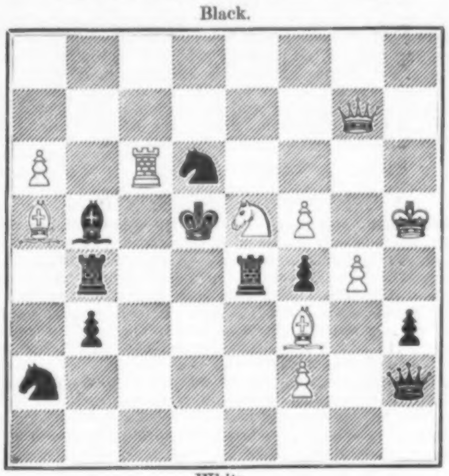
The cultivation consists in keeping the ground mellow and clean without disturbing the vines after they have commenced to spread. As it does not pay to cultivate vacant ground, if any hills are missing after a reasonable time for them to come up, other plants already started should be transplanted to the vacant places. Some planters put an extra quantity of seed in every fourth or fifth row, in order to have a surplus of plants for filling vacant spots in the other rows. Where peanuts are raised as a business, the last cultivation, or "laying by," is the most important part of the work of cultivation. This is done when the vines extend half across the row, and consists in running a plow in the center between the rows, and in drawing the earth carefully around the plants with a hoe. Care must be exercised, however, not to cover the vines. The vines should not be covered at any time during their growth, though the contrary opinion is held by nearly all who have had no experience in the cultivation of this crop. There are other points of interest in connection with this subject which must be deferred to some future time.—LANCY, *in Country Gentleman.*

SCIENTIFIC AMERICAN CHESS RECORD.

[All contributions intended for this department, may be addressed to SAMUEL LOYD, Elizabeth, N. J.]

PROBLEM No. 25. BY J. H. FINLINSON, of Huddersfield. Third best 3 mover of Centennial Tournay.

Black.



White.

White to play and mate in three moves.

J. H. FINLINSON, OF HUDDERSFIELD, ENGLAND.

White to play and mate in 3 moves.
S. LOYD.

"LABORE ET PERSEVERANTIA" was the not inappropriate motto of the set of problems that carried off the honors for the third best three and four move problems of the recent Centennial Tournament. Our readers will find them most beautiful and elaborate compositions, and we have yet to find a problemist on this side of the water who does not most heartily congratulate the author upon his well earned laurels and international victory, being the only foreign competitor who succeeded in carrying off a prize; his success being the more significant from the fact of his winning two prizes.

From the portrait that we present of Mr. Finlinson, it will be seen that he is still young in years, although he has long been recognized by composers whose opinions are deserving of weight as entitled to rank as one of England's most scientific composers, having been successful in several other competitions, besides being known as a most skillful player, as may be seen from the specimen that we give of his play selected from a recent number of the *Huddersfield College Magazine*.

We never had the pleasure of meeting Mr. Finlinson, but every feature of his frank, handsome face confirms the high estimation we entertain for his genius, and endorses the good opinions of his friends who admire him for his agreeable manners and great talents, combined with unassuming modesty.

IN the chronicle of the Moorish kings of Granada, it is related that, in 1396, Mohammed Balba seized upon the crown which inured to his elder brother, and soon became the victim of defeat and disaster. His wars with the Castilians were invariably unsuccessful, and he eventually came to his death by wearing a vest which had been impregnated with some deadly poison. Finding that he could not live, he sent an officer to the fort Salobrena, to put his brother Jusaf to death, to prevent that prince's followers from forming any obstacle to his son's succession. The officer found the prince playing at chess with a priest. Jusaf begged hard for a respite, which was at first denied, but at last conceded, and he was permitted to finish the game; but previous to its termination a messenger arrived with news of the death of Mohammed and the unanimous election of Jusaf to the Crown.

THE inhabitants of Morocco are forbidden all games of hazard by the second and fifth chapters of the Koran, but chess is permitted and forms their chief recreation. Many have obtained a masterly proficiency in the game. It is never played for money, but custom allows the victor to place a feather or straw in the turban of his defeated adversary.

WEST YORKSHIRE CHESS ASSOCIATION.

THE twenty-second annual meeting of this flourishing English chess association, which is comprised of members of the chess clubs of the principal western towns, met April 29 of the present year. There were three classes of tournaments, so that players of different force might participate. In the pairing of the first class the following was the result of the first round:

Mr. Finlinson, of Huddersfield, won of Mr. Bailey, of Bradford; Mr Soyers, Leeds, won of Mr. Whitaker, of Bradford; Mr. Barbier, Ripon, won of Mr. Francis, of Halifax; Mr. Lewis, Bradford, won of Mr. Stokoe, of Leeds.

In the second pairing Mr. Barbier won of Mr. Lewis, but as Messrs. Finlinson and Soyer were unable to arrange a meeting, the stakes were divided between these three gentlemen without concluding the tournament. As a specimen of Mr. Finlinson's play we give the following interesting game from the first round of the tournament:

J. H. FINLINSON. WHITE.	T. BAILEY. BLACK.
1. P to K 4	1. P to Q 3
2. P to Q 4	2. Kt to K B 3
3. Kt to Q B 3	3. B to K Kt 5 (*a*)
4. P to K B 3	4. B to Q 2
5. B to Q 3	5. P to K 4
6. K Kt to K 2 (*b*)	6. P x P
7. Kt x P	7. P to Q B 4
8. K Kt to K 2	8. B to K 3 (*c*)
9. P to Q Kt 3 (*d*)	9. B to K 3
10. Castles.	10. Kt to K R 4 (*e*)
11. Q R to Kt sq	11. B to K B 3
12. Kt to Q R 4	12. B to K Kt 4
13. P to K B 4	13. B to K 2
14. P to K B 5	14. B to Q 2
15. K Kt to Q B 3	15. Kt to K B 3
16. Q to K B 3 (*f*)	16. Kt to Q B 3
17. B to K B 4 (*g*)	17. Kt to Q 5
18. Q to Q sq	18. B x Kt
19. P x B	19. P to Q Kt 3
20. Kt to Kt 5	20. Kt x Kt
21. P x Kt (*h*)	21. Castles.
22. R to K B 3	22. Kt to R 4
23. B to Q 2	23. B to B 3
24. P to B 3 (*i*)	24. B to K 4
25. R to R 3	25. Kt to B 5
26. B x Kt	26. B x B
27. Q to R 5	27. P to K R 3
28. R to K B sq	28. B to Kt 4
29. R to Kt 3	29. Q to K B 3
30. B to B 2 (*j*)	30. Q to K 4
31. Q R to K B 3	31. P to Q B 5 (*k*)
32. P to K R 4	32. B to Q 7
33. Q to Kt 4	33. B to K 8
34. R to R 3 (*l*)	34. Q x Kt P (*m*)
35. P to K B 6	35. P to Kt 3
36. P to K 5	36. P to K R 4
37. Q to Kt 5 and wins.	

NOTES BY JOHN WATKINSON.

(*a*) If white on the next move replied by Kt to B 3, black would gain half a move at least, which, in high class chess, the advantages gained by the better player in the course of his game chiefly consists in gaining time, and that time may sometimes be valued at only a fraction of a move; here the move is bad and only serves to develop white's game.

(*b*) This move brings another piece into play, but it seems to us that P to Q 5 was better.

(*c*) B to K 2 seems better.

(*d*) K to Kt 3, followed by B to K 2, if pawn goes on, gives white a stronger game than the one he obtained by the move in the text.

(*e*) Mr. Bailey seems to challenge the advance of the Kt pawn, in which case it seems possible that white's game would be weakened, but such moves as these, possessing only half a chance of success, generally lead to a development of the adversary's game.

(*f*) Did white foresee the action of black's Q Kt on the 17th move?

(*g*) Better here than to Q 3, for the B Kt at K 4 would have been in a commanding position for some time.

(*h*) B x Kt ch is better, followed with moving to B sq by B to B 4.

(*i*) We have tried here P to Kt 4, and our analysis, unless we err, wins the game for white.

(*j*) B to B 4 here leads to some very interesting variations.

(*k*) A good move, shutting out the K B.

(*l*) P to B 6 is a very tempting move, but difficult to analyze over the board.

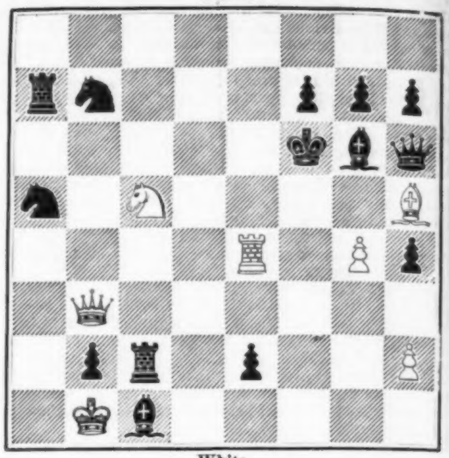
(*m*) Fatal! whilst P to K B 3 would have left black a very fair game.

NOTICE TO CORRESPONDENTS.

IN our introductory of Aug. 11, we took occasion to explain our plan of culling the choicest problems and games from all the important matches and tournaments, together with condensed accounts of the same, with portraits and biographical sketches of chess celebrities, anecdotes and historical events and such other information as would combine to form a complete book of reference, the need of which has long been felt by the chess community.

PROBLEM No. 26. BY J. H. FINLINSON, of Huddersfield. Third best 4-mover of Centennial Tournay.

Black.



White.

White to play and mate in four moves.

We have been greatly encouraged in our work, not only by the flattering notices of the press, but by the cordial endorsement of the plan by the leading players throughout the country, who seem eager to secure complete files of what they admit will be the most interesting chess encyclopædia ever attempted, and which no true lover of the game can afford to be without. We have undertaken this enterprise in a spirit of enthusiasm, regardless of labor and cost, and without expectation or desire of remuneration. It was planned several years ago, and a trip taken to Europe for the sole purpose of sketching some of the famous masters, and a large chess library has been accumulated for the purpose of reference. And while touching upon this subject we would impress upon our friends that we depend largely upon their counsel and aid in securing selections from such matches and tournaments as they knew to be worthy of record, and we trust that correspondents from all parts of the world will take an interest in the project and favor us with such information as they possess.

While thanking our friends for the lively interest they have shown, we wish to refer to a matter that has lain somewhat uneasy on our conscience. From the peculiar character of our chess department, as possessing more than a common interest to all, as well as from the high position of the journal itself, and its wide circulation among a class of readers peculiarly favorable to scientific recreations, it is no wonder that it should meet with an early encouragement, and is doubtless at the present moment the recipient of more chess communications than any other half a dozen chess departments in the world. We are more than pleased at the attention of our friends, and will most cheerfully reply to all queries appertaining to the game, and will devote a ton or two of postal cards to that particular purpose; but in conformity with our programme we feel called upon to digress from the established plan of introducing replies to correspondents, as it would be inappropriate to devote so much space to mere local or personal matters which possess no general interest. We cannot imagine how a few years hence even the parties themselves would care to find it placed on record that valuable and interesting communications have been received from E. B. Cook, Chas. A. Gilborg, W. H. Shinkman, John Gardner, Jacob Elson, J. B. McKim, J. G. Belden, T. B. Bull, J. N. Babson, James Mason, O. H. Brownson, C. H. Wheeler, and a host of others who will receive letters during the course of the week. M. Careylen, H. Edwards, and others are informed that in their proposed methods of placing five queens on the board, they have overlooked the fact that the queens themselves must be protected. C. H. Lee, of Brooklyn, is the only one who has sent us an additional correct version. W. H. Lyons, W. S. G., G. Henry, and scores of others are informed that the only faulty problem we have published is the letter "I" by Mr. Mudge, the fault being our own, as he had requested us to move all the pieces one square to the left. A number of beginners must bear in mind that a problem is merely an end game wherein one player announces a mate, which he agrees to effect in a certain number of moves against the best possible play of his adversary. H. L. F. Myer is informed that his strictures upon Mr. Finlinson's compositions are out of order, and that the proposed improvements upon a number of prize problems are not only faulty but destroy the beauty of the positions. If certain would-be critics will only devote their spare time to the improvement of their own compositions, they might give us specimens of their superior skill at the next tournament.

SOLUTIONS TO PROBLEMS.

No. 19.—BY H. E. BIRD.

WHITE.	BLACK.
1. R to Kt 6!!!	1. R x R
2. Kt x R	2. Q to B 3 or R to Kt 2 (If Q x P ch, P x Q etc.)
3. Kt (Q 3) to K 4 ch	3. Q x Kt
4. P to Q 3 mate.	
	1. Q x Kt
3. Kt to K [illegible] ch	2. K to B 4 (best)
3. Kt x [illegible]	[illegible]
4. P to Q [illegible] mate	
	1. R to B 2
2. Kt to K [illegible] ch	[illegible] 4
3. Kt (B 6) to Q 7 ch	[illegible]
4. R to B 6 mate.	

No. 20.—BY DENNIS JULIEN.

WHITE.	BLACK.
1. Q to Q 6	1. B to K 4 ch
2. R to Kt 3 ch	2. K to B 5
3. P to R 6	3. Q to B 2
4. R to Q R 4	4. Any move
5. Mates.	

LETTER "O."—BY E. B. COOK.

WHITE.	BLACK.
1. K Kt x P	1. K moves
2. B mates.	

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